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LIST OF AUTHORS.

Page.

ACHARJI, M. N.

A New species of *Oligodon* from the United Provinces (*in collaboration with Ray, H. C.*) 519

AKHTAR, S. A.

Notes on Helminth Parasites from Afghanistan . . . 373

ALLEN, GLOVER M.

Two new Races of Indian Bats 343

BARNARD, K. H.

Isopods collected by the R. I. M. S. "Investigator" . . 147

CHATTERJEE, R. C.

The Helminths Parasitic in the Fresh-water Turtles of Rangoon 81

DATTA, M. N.

Scientific Results of the Yale North India Expedition. *Biological Report No. 20.* Helminth Parasites of Fishes from North India, with special reference to Acanthocephalans . . 211

GATES, G. E.

The Earthworms of Burma 377

GATES, G. E.

On a species of *Eutyphoeus* from Calcutta (*in collaboration with Kyaw, Maung Hla*) 513

HORA, S. L.

Notes on Fishes in the Indian Museum. XXVI. On a small collection of Fish from the Chitaldrug District, Mysore . . 1

HORA, S. L.

Notes on Fishes in the Indian Museum. XXVII. On two collections of Fish from Maungmagan, Tavoy District, Lower Burma (*in collaboration with Mukerji Dev Dev*) . . . 15

HORA, S. L.

Fish of the Eastern Doons, United Provinces (*in collaboration with Mukerji Dev Dev*) 133

Page.

HORA, S. L.

Siluroid Fishes of India, Burma and Ceylon. II. Fishes of the genus *Akysis* Bleeker. III. Fishes of the genus *Olyra* McClelland. IV. On the use of the generic name *Wallago* Bleeker. V. Fishes of the genus *Heteropneustes* Müller . 199

HORA, S. L.

On a further collection of Fish from the Naga Hills . . . 317

HORA, S. L.

Sexual Dimorphism in the Carp *Lebeo dero* (Hamilton) (*in collaboration with Misra, K. S.*) 341

HORA, S. L.

Siluroid Fishes of India, Burma and Ceylon. VI. Fishes of the genus *Clarias* Gronovius. VII. Fishes of the genus *Silurus* Linnaeus. VIII. Fishes of the genus *Callichrous* Hamilton 347

KYAW, MAUNG HLA.

On a species of *Eutyphoeus* from Calcutta (*in collaboration with Gates, G. E.*) 513

MANI, M. S.

Chalcids (*Parasitic Hymenoptera*) from India 125

MANI, M. S.

A New Encyrtid Parasite (*Chalcidoidea: Hymenoptera*) of a Cockroach from India 131

MANI, M. S.

Studies on Indian Itonididae (*Cecidomyidae: Diptera*). III. On a collection of Midges from South India 193

MANI, M. S.

Some New and Little-known Parasitic Hymenoptera from India 333

MANI, M. S.

On a collection of Parasitic Hymenoptera from the Government Museum, Madras 469

MARTYNOV, A.

On a collection of Trichoptera from the Indian Museum. Part II. Integripalpia 239

Page.

MICHAELSEN, W.

Branchiura sowerbyi Beddard and its synonymy . . . 95

MISRA, K. S.

Sexual Dimorphism in the Carp *Labeo dero* (Hamilton) (*in collaboration with Hora, S. L.*) 341

MORTENSEN, TH.

Phyllacanthus forcipulatus, sp. nov., A new Cidarid from the Indian Ocean 307

MUKERJI, DEV DEV.

Notes on the Systematic Position of the two Gobioid Fishes, *Gobiella pellucida* Smith and *G. birtwistlei* Herre, with special remarks on the validity of the Genus 9

MUKERJI, DEV DEV.

Notes on Fishes in the Indian Museum. XXVII. On two collections of Fish from Maungmagan, Tavoy District, Lower Burma (*in collaboration with Hora, S. L.*) 15

MUKERJI, DEV DEV.

Fish of the Eastern Doons, United Provinces (*in collaboration with Hora, S. L.*) 133

PAULIAN, RENAUD.

Indian Aphodiinae of the Subgenus *Trichonotulus* (Coleoptera: Lamellicornia) 363

PRASHAD, B.

On the Sipunculoidea from Indian Waters in the Indian Museum, Calcutta 231

RAJA, K. C. K. E.

A statistical study of the data of Growth in shells of *Trochus niloticus* Linn. in Andaman Waters (*in collaboration with Rao, H. S.*) 499

RAO, H. SRINIVASA.

Observations on the Rate of Growth and Longevity of *Trochus niloticus* Linn. in the Andaman Is. 473

RAO, H. SRINIVASA.

A statistical study of the data of Growth in shells of *Trochus niloticus* Linn. in Andaman Waters (*in collaboration with Raja, K. C. K. E.*) 499

Page.

RAO, K. VIRABHADRA.
The Morphology of *Kalinga ornata* (Ald. & Han.) 41

RAY, H. C.
A New species of *Oligodon* from the United Provinces (India), (*in collaboration with Acharji, M. N.*) 519

SUBRAHMANIAN, K.
Studies on the Acanthocephalan Fauna of Burma 311

VENKATRAMAN, T. V.
The Biology of the Shore-fly, *Sarcophila cinerea* Fabricius (Diptera : Metopiidae) 367

VERHOEFF, K. W.
Ueber einige Isopoda aus Süd-Indien 97

VERHOEFF, K. W.
Ueber einige Indische Chilognathen gesammelt von Herrn S. Jones, Madras 103

VERHOEFF, K. W.
Ueber einige Myriapoden und Isopoden aus Dekan, gesammelt von Herrn S Jones, Madras 503

CONTENTS.

Page.

PART I.—*Published March, 1937.*

Description of Two New Species of *Symphylurinus* (*Dicellura*, Family Projapygidae) from India and China 1

Notes on Fishes in the Indian Museum. XXVIII. On Three Collections of Fish from Mysore and Coorg, South India . . . 5

Descriptions of Three New Hydrophilidae from India . . . 29

Coleoptera Palpicornia from the Khewra Gorge, Salt Range, Punjab 33

Notes on Fishes in the Indian Museum. XXIX. On a Collection of Fish from Nepal 43

On the Habitat and Habits of *Trochus niloticus* Linn. in the Andaman Seas 47

Seasonal Variations in the Distribution of *Sagitta* in the Madras Coast 83

PART II.—*Published July, 1937.*

Trois Cyclopides (Crustacés Copépodes) Nouveaux de l'Inde . . 99

On a Collection of Indian Earthworms of the family Lumbricidae . 105

Notes on the Larva and Pupa of *Amphipsyche indica* Martinov [Insecta : Trichoptera] 113

Changes in the Internal Structure of the Air-bladder of *Pangasius pangasius* (Ham.) during growth 117

On three Chalcidoid parasites of cotton borer Beetles from South India 125

On a new species of *Neoechinorhynchus* parasitic on *Mugil cephalus* Linn. from the Chilka Lake 129

Skull of *Varanus monitor* (Linn.) 133

Indian Earthworms. I. The Genus *Pheretima* 175

PART III.—*Published September, 1937.*

A Review of the Genus *Lygosoma* (Scincidae : Reptilia) and its allies 213

Catfishes of the Genus *Helicophagus* Bleeker 235

Comparison of the Fish-faunas of the Northern and the Southern faces of the Great Himalayan Range 241

Distribution of the Himalayan Fishes and its bearing on certain Palaeogeographical problems 251

Scientific Results of the Yale North India Expedition. Biological Report No. 21. Aquatic and Amphibious Molluscs . . . 261

Page.

Studies on Indian Itonididae (Cecidomyidae: Diptera). IV. Eight New Midges 281

Revision of the Indian Chalcid Wasps of the Sub-family Leucospidinae (Parasitic Hymenoptera) 287

Acanthocephala from India. Description of the Male of *Eosentis rigidus* Van Cleave occurring in the intestine of *Schizothorax zarudnyi* from Seistan 303

PART IV.—*Published December, 1937.*

Indian Earthworms. II. *Scolioscolides*, gen. nov. 305

Systematic Position, Geographical Distribution and Evolution of the Cyprinoid genera with a Procumbent Predorsal Spine. . 311

Notes on Fishes in the Indian Museum. XXX. On the Systematic Position of *Cyprinus cosuatis* Hamilton. XXXI. On a Small Collection of Fish from Sandoway, Lower Burma. XXXII. On a small Collection of Fish from the Upper Chindwin Drainage. XXXIII. On a Collection of Fish from the Kumaon Himalayas. XXXIV. On a New Catfish from Kwansi, China. XXXV. A Further Note on Hamilton's *Cyprinus* (*Garra*) *lamta*. XXXVI. On a New Genus of Chinese Catfishes allied to *Pseudecheneis* Blyth 321

The Indian Ephemeroptera (Mayflies) of the Sub-order Ephemeroidea 351

Notes on *Nevadne glauca* (Annandale) 371

Further Notes on Crustacea Decapoda in the Indian Museum. IX. On Three Collections of Crabs from Tavoy and Mergui Archipelago 377

Structure, Habits and Early Development of a New Species of *Stiliger* Ehrenberg 435

LIST OF PLATES.

			Follow page.
Plate	I.	*Trochus niloticus* Linn.	82
Plate	II.	Trois Cyclopides noveaux de l'Inde	104
Plate	III.	Trois Cyclopides noveaux de l'Inde	104
Plate	IV.	Indian Ephemeroptera	370
Plate	V.	Indian Ephemeroptera	370
Plate	VI.	Crabs from Tavoy and Mergui	434
Plate	VII.	*Stiliger gopalai*, sp. nov.	464
Plate	VIII.	*Stiliger gopalai*, sp. nov.	464
Plate	IX.	*Stiliger gopalai*, sp. nov.	464

LIST OF AUTHORS.

Page.

AYYAR, T. V. RAMAKRISHNA.

On three Chalcidoid parasites of Cotton borer Beetles from South India (*in collaboration with Mani, M. S.*) 125

BAHL, K. N.

Skull of *Varanus monitor* (Linn.) 133

ČERNOSVITOV, L.

On a Collection of Indian Earthworms of the family Lumbricidae 105

CHOPRA, B.

Further Notes on Crustacea Decapoda in the Indian Museum. IX. On Three Collections of Crabs from Tavoy and Mergui Archipelago (*in collaboration with Das, K. N.*) 377

DAS, K. N.

Further Notes on Crustacea Decapoda in the Indian Museum. IX. On Three Collections of Crabs from Tavoy and Mergui Archipelago (*in collaboration with Chopra, B.*) 377

DATTA, M. N.

Acanthocephala from India. Description of the male of *Eosentis rigidus* Van Cleave occurring in the intestine of *Schizothorax zarudnyi* from Seistan 303

D'ORCHYMONT, A.

Descriptions of Three New Hydrophilidae from India . . . 29

D'ORCHYMONT, A.

Coleoptera Palpicornia from the Khewra Gorge, Salt Range, Punjab 33

GATES, G. E.

Indian Earthworms. I. The genus *Pheretima* 175

GATES, G. E.

Indian Earthworms. II. *Scolioscolides*, gen. nov. 305

HAFIZ, H. A.

Notes on the Larva and Pupa of *Amphipsyche indica* Martinov [Insecta: Trichoptera] 113

Page.

HAFIZ, H. A.

The Indian Ephemeroptera (Mayflies) of the sub-order Ephemeroidea 351

HORA, SUNDER LAL.

Notes on Fishes in the Indian Museum. XXVIII. On Three Collections of Fish from Mysore and Coorg, South India . 5

HORA, SUNDER LAL.

Notes on Fishes in the Indian Museum. XXIX. On a Collection of Fish from Nepal 43

HORA, SUNDER LAL.

Catfishes of the genus *Helicophagus* Bleeker 235

HORA, SUNDER LAL.

Comparison of the Fish-faunas of the Northern and the Southern faces of the Great Himalayan Range 241

HORA, SUNDER LAL.

Distribution of Himalayan Fishes and its bearing on certain Palaeogeographical problems 251

HORA, SUNDER LAL.

Systematic Position, Geographical Distribution and Evolution of the Cyprinoid genera with a Procumbent Predorsal Spine . 311

HORA, SUNDER LAL.

Notes on Fishes in the Indian Museum. XXX. On the Systematic Position of *Cyprinus cosuatis* Hamilton. XXXI. On a small Collection of Fish from Sandoway, Lower Burma. XXXII. On a small Collection of Fish from the Upper Chindwin Drainage. XXXIII. On a Collection of Fish from the Kumaon Himalayas. XXXIV. On a New Catfish from Kwansi, China. XXXV. A Further Note on Hamilton's *Cyprinus* (*Garra*) *lamta*. XXXVI. On a New Genus of Chinese Catfishes allied to *Pseudecheneis* Blyth 321

JOHN, C. C.

Seasonal Variations in the Distribution of *Sagitta* of the Madras Coast 83

LINDBERG, K.

Trois Cyclopides (Crustacés Copépodes) Nouveaux de l'Inde . 99

Page.

MANI, M. S.

On three Chalcidoid parasites of Cotton borer Beetles from South India (*in collaboration* with Ayyar, T. V. Ramakrishna) 125

MANI, M. S.

Studies on Indian Itonididae (Cecidomyidae: Diptera). IV. Eight New Midges 281

MANI, M. S.

Revision of the Indian Chalcid Wasps of the Sub-family Leucospidinae (Parasitic Hymenoptera) 287

NAIR, K. KRISHNAN.

Changes in the Internal Structure of the Air-bladder of *Pangasius pangasius* (Ham.) during growth 117

PANIKKAR, N. KESAVA.

Notes on *Nevadne glauca* (Annandale) 371

PODDER, T. N.

On a new species of *Neoechinorhynchus* parasitic on *Mugil cephalus* Linn. from the Chilka Lake 129

PRASHAD, BAINI.

Scientific Results of the Yale North India Expedition. Biological Report No. 21. Aquatic and Amphibious Molluscs . 261

RAO, H. SRINIVASA.

On the Habitat and Habits of *Trochus niloticus* Linn. in the Andaman Seas 47

RAO, K. VIRABHADRA.

Structure, Habits and Early Development of a New Species of *Stiliger* Ehrenberg 435

SILVESTRI, FILIPPO.

Description of Two New Species of *Symphylurinus* (*Dicellura*, Family Projapygidae) from India and Ceylon 1

SMITH, MALCOLM A.

A Review of the genus *Lygosoma* (Scincidae: Reptilia) and its Allies 213

DESCRIPTION OF TWO NEW SPECIES OF *SYMPHYLURINUS* (*DICELLURA*, FAMILY PROJAPYGIDAE) FROM INDIA AND CHINA.

By FILIPPO SILVESTRI, *Portici, Italy.*

In a collection of Thysanura and Dicellura kindly submitted to me for study by the Zoological Survey of India I found a specimen of *Symphylurinus*, the first collected in India, which appears to belong to a new species and is described in this note together with another new species collected by me in China.

The genus is represented in Africa and in Central and South America by a few species.

Symphylurinus indicus, sp. nov.

(Text fig. I).

♀ Corpus ochroleucum ; caput supra setis brevioribus parum numerosis et nonnullis brevibus, setis postantennalibus sublateralibus μ 70 longis ad apicem vix barbulatis ; labri seta postica mediana sat longa submedianis subaequali ; antennae 23-articulatae, articulo 2° quam 1um c. $\frac{1}{4}$ longiore, setis et sensillis consuetis *vide* fig. I, 1 ; palpo labiali c. $\frac{3}{4}$ longiore quam latiore.

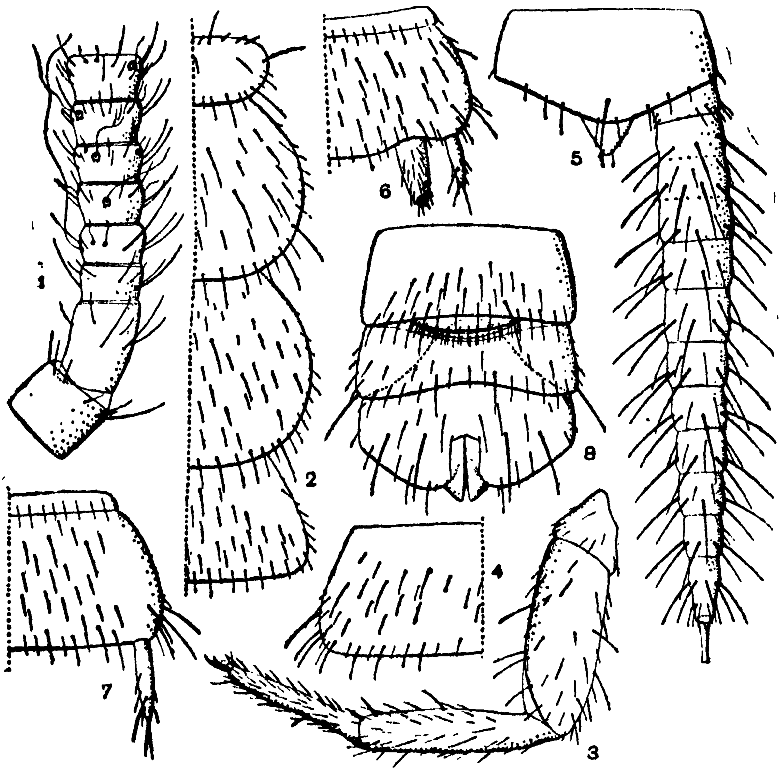
Thorax : pronotum macrochaetis 4+4 barbula minima auctis, lateralibus μ 75 longis, superficie cetera praeter setas marginales subnuda, (tantum setis brevibus duabus) ; mesonotum macrochaetis 7+7, quarum 1+1 subanticis, submedianis dispositione consueta, superficie cetera setis paucis instructa ; metanotum macrochaetis 5+5 cetero mesonoto simili.

Sterna setis consuetis maioribus barbulis 1—2 auctis instructa.

Pedes primi paris tibiae strigili apicali setis spatuliformibus 6 composita ; tertii paris trochanthero macrochaetis brevibus inferis 2, femore macrochaetis 2 superis, macrochaetis inferis submediana et apicalibus 2 longis barbulis 1—2 auctis, tibia macrochaeta ventrali submediana brevi barbula minima aucta, calcaribus apicalibus attenuatis, integris, praetarsi ungue postico quam anticus c. $\frac{1}{5}$ longiore.

Abdomen : tergitum 1um macrochaetis anticis submedianis 1+1 et 1+1 posticis etiam submedianis ; tergitum 2um macrochaetis anticis 1+1 et 2+2 posticis ; 3um macrochaetis anticis 3+3, posticis 4+4 brevibus et barbula minima auctis, superficie cetera setis brevioribus parce numerosis et nonnullis brevibus marginalibus ; tergita 4—7 macrochaetis subanticis 4+4 (laterali inclusa et a prima ad quartam gradatim a margine antico remotis), et 4+4 posticis, quarum lateralis μ 78 longa est ; tergitum 8um macrochaetis posticis 4+4, 9um 3+3 ; tergitum 10um setis minimis anticis 2+2, macrochaeta subpostica mediana quam setae marginales submedianae breves aliquantum longiore, setis marginalibus sublateralibus-submedianis, quam submedianae paullum longioribus, ceteris quam submedianae gradatim minoribus.

Urosternum primum macrochaetis anticis 3+3, posticis 4+4 barbulis 1—2 instructis, processibus subcoxalibus gradatim parum attenuatis quam stili, μ 68 longi, parum longioribus; urosterna 2—7 macrochaetis anticis 1+1, posticis 4+4, plerisque barbula minima auctis, superficie cetera setis brevibus et brevioribus parce numerosis, stilis consuetis; urosternum 8um macrochaetis posticis submedianis 1+1.



Text-fig. 1.—*Symphylurinus indicus*, sp. nov. 1. antennae laevae pars proximalis prona; 2. thoracis et urotergiti primi dimidia pars prona; 3. pes paris tertii; 4. urotergiti quinti dimidia pars prona; 5. urotergitum decimum cum lamina supranali et cerco dextero; 6. urosterni primi dimidia pars; 7. urosterni quinti dimidia pars; 8. urosterna 8um ad 10um prona.

Apertura genitalis setis anticis 12 et 14 posticis instructa.

Cerci 13-articulati, articulis a tertio ad penultimum setis brevibus proximalibus etiam instructis.

Long. corporis mm 2·10, lat. capitis 0·48, long. antennarum 1·30, pedum paris tertii 1·10, cercorum 0·80.

Habitat. Exemplum vidi ad Helvak, Koyna Valley, Satara District a F. H. Gravely lectum.

Symphylurinus orientalis, sp. nov.

(Text-fig. 2).

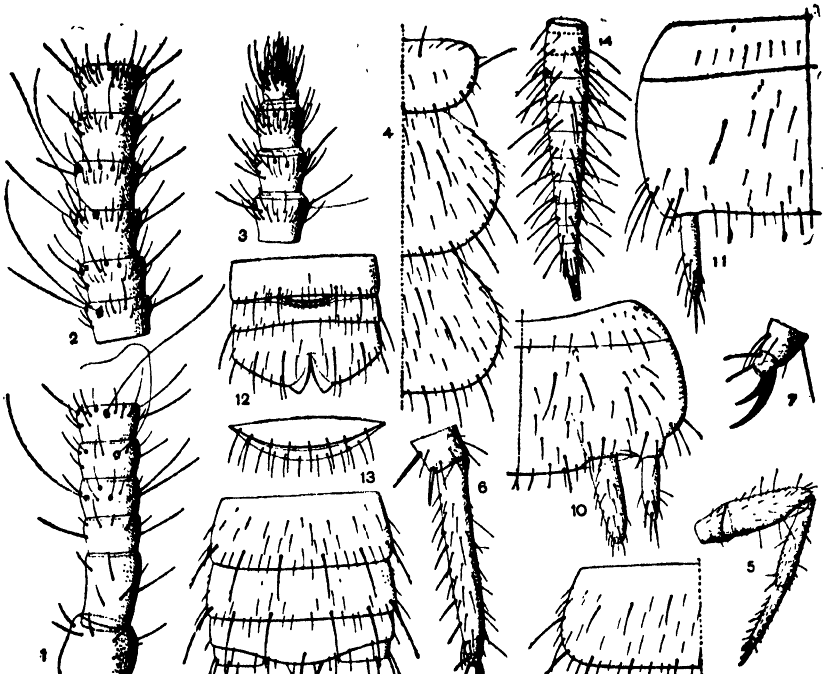
♀ Corpus cremeum; caput setis paucis brevioribus et nonnullis brevibus, omnibus integris vel setis majoribus barbula vix auctis;

antennae 23-articulatae, sensillis consuetis et setis *vide* fig. 2, 1—3; palpo labiali c. $\frac{1}{3}$ longiore quam latiore.

Thorax. Pronotum macrochaetis 4+4 subtilibus sat longis, lateralibus μ 110 longis, barbula minima auctis, superficie cetera setis paucioribus brevioribus et brevibus instructa; mesonotum macrochaetis 8+8, quarum 2+2 subanticae, 3—3 transverse submedianae, 3+3 posticis, superficie cetera setis paucioribus brevioribus et brevibus; metanotum macrochaetis 5+5, quarum 1+1 subanticae, 1+1 trasverse submedianae et 3+3 posticae cetero metanoto submile.

Sterna praesternis et furcosternis macrochaetis consuetis.

Pedes setosuli, primi paris tibiae apicis strigili setarum spatuliformium 5—6 serie instructa, tertii paris trochantero subtus macrochaetis brevibus subtilibus integris 2, femore macrochaetis superis 3 et duabus inferis parum longis integris vel barbula minima tantum auctis, tibia macrochaetis duabus superis et macrochaeta ventrali submediana subtilibus brevibus, calcaribus attenuatis simplicibus, praetarsi unguibus parum arcuatis, postico quam anticus c. $\frac{1}{4}$ longiore.



Text-fig. 2.—*Symphylurinus orientalis* sp. nov. 1. antennae laevae pars proximalis prona; 2. antennae laevae articuli 7us ad 11um proni; 3. antennae laevae pars distalis; 4. thoracis dimidia pars prona; 5. pes paris tertii; 6. eiusdem tibiae apex, tarsus et praetarsus; 7. tarsi apex et praetarsus magis ampliati; 8. urotergiti quinti dimidia pars; 9. corporis pars postica a segmento octavo prona cum cercorum articulo basali; 10. urosterni primi dimidia pars; 11. urosterni quinti dimidia pars; 12. urosterna 8um ad ultimum; 13. valvulae genitales magis ampliatae; 14. cercus laevus pronus.

Abdomen. Tergitum 1um macrochaetis anticis 1+1 et 1+1 posticis submedianis, 2um macrochaetis anticis 1+1, posticis 2+2, tergita 3—7

subsimilia macrochaetis anticis 4+4 et 4+4 posticis, barbulis minimis 1—3 auctis, superficie cetera setis brevioribus et brevibus paucis instructa ; tergitum 8um macrochaetis posticis 3+3, 9um etiam 3+3, 10um macrochaeta subpostica mediana quam setae marginales submedianae breviores duplo vel parum magis longiore.

Urosternum primum macrochaetis anticis 3+3, posticis 4+4, processibus subcoxalibus elongatis paullum attenuatis, quam stili (μ 90 longi) aliquantum longioribus ; urosterna 2—7 macrochaetis anticis 2+2 et 4+4 posticis, stilis elongatis setis simplicibus ; urosternum 8um macrochaetis posticis 2+2, 9um macrochaetis 1+1 sublateralibus, 10um macrochaetis 2+2 transverse submedianis.

Cerci 13-articulati (semper primo anuliformi et ultimo tubiformi inclusis) articulo secundo brevissimo a 3° male distincto et tantum seta nonnulla sat longa instructo, 3° etiam a 4° parum distincto sed serie setarum completa, ceteris bene distinctis setis consuetis *vide* fig. 2, 14.

Long. corporis mm 3·10, lat. capitis 0·50, long. antennarum, 1·30, pedum paris tertii 1·10, cercorum 0·78.

Habitat. Exemplum typicum ad Canton in humo et paratypum ad Tungshan (Canton, China) legi.

Observatio. Species haec ad *S. grassii* Silv. perproxima est, sed cercorum articulorum numero et articulo antepenultimo etiam setis brevibus destituto saltem distincta est.

NOTES ON FISHES IN THE INDIAN MUSEUM.

XXVIII.—On Three Collections of Fish from Mysore and Coorg, South India.

By Sunder Lal Hora, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta.*

The three collections of fish which form the subject matter of this note were made by three different collectors from varied types of habitats. Mr. B. S. Bhimachar's material was collected mainly from the Tunga river at Shimoga, but he also obtained specimens from tanks, other rivers and torrential streams in the Mysore State. Dr. H. S. Rao's collection mainly consists of pool-, surface- and mud-living species from the Shimoga and Kadur Districts, whereas Prof. C. R. Narayan Rao's material was obtained from the headwaters of the Cauvery river in Coorg where it is a sluggish stream with a sandy or muddy bed.

From a zoo-geographical point of view the Mysore plateau is of exceptional interest, as it is on the borderland between the 'Deccan tract' and the 'Carnatic or the Madras tract' of Blanford. Blanford included it in the Carnatic tract but remarked: "Perhaps the Mysore plateau, from Bellary to Bangalore and the Nilgiris, should have been included in this tract [Deccan] rather than in the Carnatic."[1] It is fortunate, therefore, that I have been afforded an opportunity to examine extensive material from this region.

Our knowledge of the freshwater fishes of South India is mainly derived from the works of Jerdon[2] and Day,[3] but unfortunately Jerdon was not quite familiar with the specific limits of the species described by Hamilton[4] from the Ganges and, in consequence, the correct definition of the species recorded by him is a matter of considerable difficulty, and in the absence of the type material his species can only be identified by studying fresh collections made from type localities. In his earlier work, such as on the "Fishes of Malabar", Day also suffered from precisely the same handicap as Jerdon and later, when he became familiar with the fishes of other parts of India, he changed his views regarding taxonomy of a number of species so radically that only a confusing mass of literature is left behind which can only be sorted and sifted by an examination of material from type localities.

The earlier naturalists, such as Bloch,[5] Cuvier and Valenciennes[6] described a large number of Indian species from specimens collected in Malabar. Some of these species have now proved to be widely distributed, while others are restricted to the Peninsula. The fauna of

[1] Blanford, *Phil. Trans. Roy. Soc. London* (B), CXCIV, p. 345 (1901).
[2] Jerdon, *Madras Journ. Litt. & Sci.*, XV, pp. 139-149, 302-346 (1848).
[3] Day, *Faun. Brit. Ind. Fish.* 2 vols. (1889).
[4] Hamilton, *Fish. Ganges* (1822).
[5] Bloch, *Naturges. ausländ. Fische*, 3 vols. (1784-95).
[6] Cuvier & Valenciennes, *Hist. Nat. Poiss.*, 22 vols. (1828-49).

the Western Ghats extends not only all along the range but spreads over to the hills of the Peninsula. In consequence, several species described by Sykes[1] from Poona and the adjoining country have been found in the Mysore plateau ; the material under report has thus enabled me to define the precise specific limits of some of Sykes' species.

In recent years Prof. C. R. Narayan Rao[2] contributed two papers on the fish of Mysore and last year I[3] reported on a small collection of fish from the Chitaldrug District. Here I propose to describe the three collections of fish separately, noting in each case the ecological conditions under which the specimens were collected. Three new species are described, while notes are added on a number of rare forms. As the taxonomy of the large-scaled Barbels of South India (fish of the *Mahseer* or *Barbus tor* type) is considerably involved, the treatment of the few specimens of this type in the collections under report is deferred till a monographic study of these fishes is undertaken.

My grateful thanks are due to Prof. C. R. Narayan Rao and Mr. B. S. Bhimachar for their kindness in presenting very valuable collections to the Zoological Survey of India.

1. MR. B. S. BHIMACHAR'S COLLECTION FROM THE MYSORE STATE.

Mr. B. S. Bhimachar of the Zoology Department, Intermediate College, Bangalore, made a collection of fish in the Tunga River at Shimoga (December, 1935), in the Western Ghats (May, 1936) and several other places in the Mysore State. The material, which contains a number of rare forms and a new species of *Nemachilus*, has now been presented to the Zoological Survey of India. At my request Mr. Bhimachar has very kindly sent to me the following observations on the ecology and bionomics of some of the species represented in his collection :—

"The majority of forms in my present collection were obtained from the Tunga river, about half a mile from the railway bridge upwards, near Shimoga. The Tunga River takes its origin in the Western Ghats and flows north-east till it joins the Bhadra at Kudali, a village 9 miles from Shimoga. The Tungabhadra, thus formed, is the main tributary of the river Krishna.

The Tunga River has a wide bed with perennial water and mostly flows over a rocky basin. It is a fast flowing stream like the other South Indian rivers. In the rainy season the river swells up considerably and the water is then muddy. In all other parts of the year the water is crystal clear and is well known for its sweet taste. Though there are some shrubs on the sandy islands in the bed of the river there is really no vegetation in the river itself, except for a good growth of algae on the rocks over which a strong current of water flows.

I have observed *Garra* attached to these rocks. They move very slowly on the rocks without completely detaching themselves from the substratum. As they move they scrape the surface of the rock and devour the algae which form their main food. *Glyptothorax* is scarce in number and is occasionally seen attached to the rocks. Both *Garra* and *Glyptothorax* are difficult to spot out since their upper surface is dark like the rocks. The loaches (*Nemachilus* and *Nemachilichthys*) are found on gravelly bed in shallow water. They do not swim about like other fishes and it is rather difficult to observe them even in clear, shallow water, unless disturbed. The stripes on the body, no doubt, make them conspicuous from the side but viewed from above these

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[1] Sykes, *Trans. Zool. Soc. London*, II, pp. 349-378 (1841).

[2] Rao, *Ann. Mag. Nat. Hist.*, (9) VI, pp. 45-64 (1920); Rao & Seshachar, *Half-yearly Journ. Mysore Univ.*, I, No. 2, pp. 1-29 (1927).

[3] Hora, *Rec. Ind. Mus.*, XXXVIII, pp. 1-7 (1936).

fishes are difficult to make out because the colour matches with the gravelly bed of the river. The other forms, particularly the Cyprinoids, are confined to the deeper pools in the bed of the river and avoid the rapid current of water.

The western part of the Mysore State is known as 'Malnad', which means hilly-country. The hills of this region form the spurs of the Western Ghats. There are thick forests in this area, with a number of rapidly flowing streams, the smaller ones of which dry up in summer. The physical conditions of the country (the slopes of the hills and the climate) are well suited for the growth of coffee and cardamom. In one of the streams flowing in a coffee plantation I have collected *Bhavania annandalei* and *Nemachilus striatus*. This particular stream is on the road-side between Kottigehar and Balehonnur."

Mr. B. S. Bhimachar's material contains a specimen of *Ophicephalus gachua* with an abnormal dorsal fin collected by Dr. B. Thirumalachar in a tank near Mysore and a specimen of *O. punctatus* without the ventral fins. The latter abnormality was noticed in the practical classes by Mr. T. Ramachandra Rao.

Besides the two localities mentioned in Mr. Bhimachar's note fishes were also collected from (i) stream near Kottigehar village, (ii) a tank at Taluguppe village near Sagar, Shimoga District, (iii) Bangalore, (iv) Bhadra river, (v) Bethmangala tank, and (vi) Sulekere tank. The entire collection is listed below according to the localities.

Tunga River at Shimoga.

1.	*Mastacembelus armatus* (Lacép.)	2 specimens.
2.	*Garra bicornuta* Rao	3 specimens.
3.	*Garra jerdonii* (Day)	6 specimens.
4.	*Labeo porcellus* (Heckel)	4 specimens.
5.	*Barbus pinnauratus* (Day)	2 specimens.
6.	*Barbus* sp. (Large-scaled Barbel)	1 specimen.
7.	*Barbus dorsalis* (Jerdon)	2 specimens.
8.	*Barbus kolus* Sykes	1 specimen.
9.	*Barbus ticto* (Ham.)	1 specimen.
10.	*Barbus sophore* (Ham.)	1 specimen.
11.	*Cirrhina fulungee* (Sykes)	4 specimens.
12.	*Scaphiodon nashii* (Day)	4 specimens.
13.	*Rasbora daniconius* (Ham.)	3 specimens.
14.	*Esomus barbatus* (Jerdon)	3 specimens.
15.	*Danio strigillifer Myers*	5 specimens.
16.	*Danio malabaricus* (Jerdon)	1 specimen.
17.	*Barilius bendelisis* Ham.	2 specimens.
18.	*Barilius barila* Ham.	1 specimen.
19.	*Barilius barna* Ham.	6 specimens.
20.	*Labauca atpar* (Ham.)	4 specimens.
21.	*Chela argentea* Day	9 specimens.
22.	*Nemachilus bhimachari*, sp. nov.	1 specimen.
23.	*Nemachilus anguilla* Annandale	1 specimen.
24.	*Nemachilus denisonii* Day	2 specimens.
25.	*Nemachilichthys shimogensis* Rao	5 specimens.
26.	*Lepidocephalichthys thermalis* (C. & V.)	9 specimens.
27.	*Glyptothorax dekkanensis* (Günther)	1 specimen.
28.	*Xenentodon cancila* (Ham.)	1 specimen.
29.	*Ophicephalus gachua* Ham.	4 specimens.
30.	*Ambassis ranga* (Ham.)	5 specimens.
31.	*Glossogobius giuris* (Ham.)	2 specimens.

A stream on the road-side between Kottigehar and Balehonnur, Western Ghats.

1. *Bhavania annandalei* Hora . . . . . . 4 specimens.
2. *Nemachilus striatus* Day . . . . . . 10 specimens.

A stream near Kottigehar Village, Western Ghats.

1. *Barbus ticto* (Ham.) . . . . 11 specimens.
2. *Barbus melanampyx* Day . . . . . . 6 specimens.
3. *Brachydanio rerio* (Ham.) . . . . . . 6 specimens.

A tank at Taluguppe Village near Sagar, Shimoga District.

1. *Nemachilus dayi* Hora . . . . . . 3 specimens.
2. *Lepidocephalichthys thermalis* (C. & V.) . . . . 5 specimens.
3. *Panchax lineatus* C. & V. . . . . . . 2 specimens.

Round about Bangalore.

1. *Barbus kolus* Sykes . . . . 1 specimen.
2. *Chela clupeoides* (Bloch) . . . . . . 2 specimens.
3. *Nemachilus denisonii* Day . . . . . . 1 specimen.
4. *Nemachilus striatus* Day . . . . . . 9 specimens.

Sulekere tank.

1. *Barbus ticto* (Ham.) . . . . 1 specimen.
2. *Chela clupeoides* (Bloch) . . . . . . 1 specimen.

Bethmangala tank.

1. *Nemachilus denisonii* Day . . . . . . 13 specimens.

Bhadra river.

1. *Barbus sophore* (Ham.) . . . . . . 1 specimen.
2. *Rasbora daniconius* (Ham.) . . . . . . 1 specimen.
3. *Esomus barbatus* (Jerdon) . . . . . . 1 specimen.
4. *Barilius bendelisis* (Ham.) . . . . . . 2 specimens.

As has been indicated above there is only one new species in Mr. Bhimachar's collection, but the material has enabled me to add notes on a few rare and interesting forms, such as *Labeo porcellus*, *Barbus pinnauratus*, *Scaphiodon nashii*, *Danio strigillifer*, *Bhavania annandalei*, *Nemachilus striatus*, *N. anguilla*, *Glyptothorax dekkanensis* and two abnormal specimens of *Ophicephalus*. Attention may specially be directed to the nature of the gill-openings in *Bhavania* which are small and restricted above the base of the pectoral fins. Among the Homalopterinae, as a rule, the gill-openings are fairly wide ; but in *Bhavania* the form of these structures corresponds with that found in several genera of the Gastromyzoninae, such as *Gastromyzon*, *Neogastromyzon*, *Beaufortia*, *Sewellia*, and *Pseudogastromyzon*. The discovery of *Danio strigillifer* from S. India deserves special mention, as the species was only recently described by Myers from Upper Burma and has not so far been found in India proper. The occurrence of abnormal forms among the Ophicephalidae is not rare, but the two cases reported here

are of exceptional interest, firstly because the abnormality of the dorsal fin is rare and secondly because the absence of the ventral fins, though common in *O. gachua*, is of rare occurrence in the other species.

Labeo porcellus (Heckel).

1877. *Labeo porcellus*, Day, *Fish. India*, p. 539, pl. cxxviii, fig. 1.

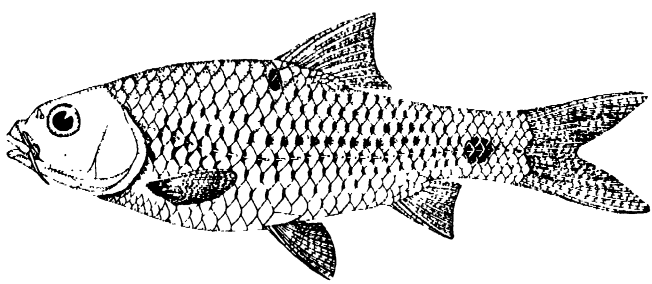
Labeo porcellus has hitherto been known from Bombay and Poona. Mr. Bhimachar obtained 4 specimens, 92-119 mm. in total length, from the Tunga river at Shimoga. It is evidently a small species, as no specimen over 7 inches in length has been found so far.

The upper lip and the rostral fold are slightly fimbriated, whereas the lower lip is strongly papillated. The papillae are long and slender and cover the entire exposed part of the lip. Such a condition of the lip seems to be antecedent to that found in *Labeo dero* (Ham.)[1] and some other Himalayan species. A transverse groove and a number of open pores on the snout are also present in *L. porcellus*.

Barbus pinnauratus (Day).

1877. *Barbus pinnauratus*, Day, *Fish. India*, p. 561, pl. cxxxix, fig. 3.

Barbus pinnauratus is represented by two young specimens, 85 and 94 mm. in total length respectively, collected from the Tunga river



TEXT-FIG. 1.—Lateral view of a specimen of *Barbus pinnauratus* (Day) from the Tunga River. Nat. Size.

at Shimoga. Besides the characteristic colouration of the species as described by Day, in the specimens under report there is a short, somewhat oblique, deep black mark below the dorsal spine.

Scaphiodon nashii (Day).

1931. *Scaphiodon nashii*, Mukerji, *Journ. Bombay Nat. Hist. Soc.*, XXXV, p. 169, fig. 3.

Mr. B. S. Bhimachar collected 4 specimens of *Scaphiodon nashii* from the Tunga river at Shimoga; they are from 84 to 104 mm. in total length. The structure of the mouth, lips and jaws is more or less similar to that described and figured by Mukerji in 3 specimens, 92, 95 and 104 mm. in length respectively; while in the smallest specimen

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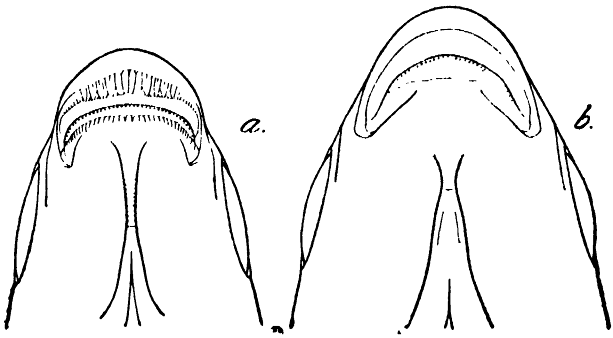
[1] Hora & Mukerji, *Rec. Ind. Mus.*, XXXVIII, p. 142 (1933); Hora, *ibid.*, p. 320.

the mouth is broad and is very much like that of an *Osteochilus*. According to Day "In the young the jaws are compressed, each with a cartilaginous covering: the lips at the angle are thick and continuous, not



TEXT-FIG. 2.—Ventral surface of head of a young and a half-grown specimen of *Scaphiodon nashii* (Day), showing changes in the nature of mouth, jaws and lips. ×3½.

a. From a specimen 65 mm. in length without the caudal.

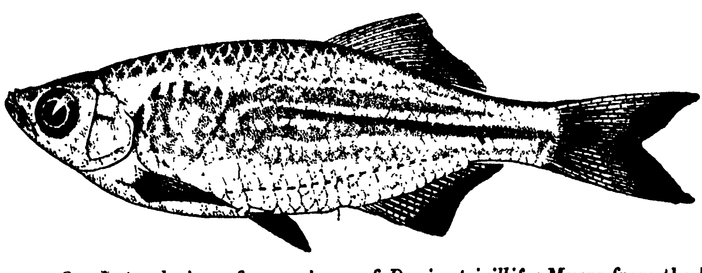
b. From a specimen 82 mm. in length without the caudal.

continued across the chin. As age increases the mouth widens, the cartilaginous covering becomes more horny, and the colours of the fish alter." It seems probable that in writing up his note Day erroneously attributed the structure of the young to the adult specimen. One of the specimens of *Scaphiodon nashii* examined by Day is stated to have been 4 inches (approximately 100 mm.) in length. The other two specimens noted to have been collected in South Canara were probably smaller as they showed characters of "*Osteochilus malabaricus*". The structure of the mouth and associated parts of the two stages is figured here for future reference.

Danio strigillifer Myers.

1924. *Danio strigillifer*, Myers, *Amer. Mus. Novitates*, No. 150, p. 1.

Danio strigillifer was described by Myers from two specimens collected at Myaing in Upper Burma. The South Indian specimens, which I now



TEXT-FIG. 3.—Lateral view of a specimen of *Danio strigillifer* Myers from the Tunga river. ×1½.

refer to this species, agreed so closely with Myers' description that they could not be separated from it by any well marked character. Since the occurrence of precisely the same form in such widely separated

localities was a matter of cosiderable significance I sent a specimen to Dr. J. T. Nichols, Curator of Recent Fishes at the American Museum of Natural History, and requested him to compare it with the type-specimen of Myers' species. He has replied as follows :—

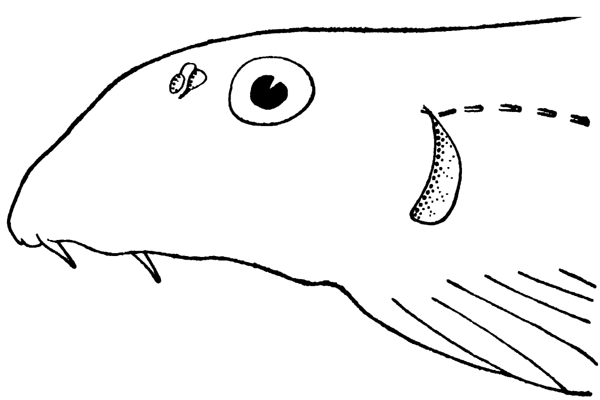
"I have just compared the specimen that you sent with Myers' *D. strigillifer*, American Museum No. 8351, and believe they are the same thing. The specimens are not in a very good state of preservation with colour almost entirely faded out, and I was unable to make out the barbels satisfactorily, but notice that Myers described them as in your fish."

There are a number of genera, such as *Silurus*, *Thynnichthys* and *Homaloptera* (*s. l.*), which are common to Burma, Assam Hills, Eastern Himalayas and South India, but, so far as I am aware, there is no record of any Indian species with such a discontinuous range of distribution.

Bhavania[1] **annandalei** Hora.

1920. *Bhavania annandalei*, Hora, *Rec. Ind. Mus.*, XIX, p. 203, pl. x, figs. 1·3 ; pl. xi, figs. 5·7.

The South Indian members of the family Homalopteridae had been so much confused with those occurring in the Darjeeling Himalayas and the hill ranges of Assam that considerable difficulty was experienced in separating them. Finally, however, Homalopteridae of India[2] were grouped into three genera, *viz.*, *Balitora* Gray from the Darjeeling Himalayas, the Assam hill ranges and Upper Burma, *Homaloptera* van Hasselt from Tenasserim and *Bhavania* Hora from the hill ranges of the Peninsula. The description of the last genus was based on immature specimens of two species which differed from *Balitora* in the form of the pectoral



TEXT-FIG. 4.—Lateral view of head and anterior part of body of *Bhavania annandalei* Hora, showing the position and extent of its gill-opening. $\times 4\frac{1}{2}$.

fins and the number of rays in them. When material of extra Indian species of *Homaloptera* became available in the Indian Museum for

[1] Prashad & Mukerji (*Rec. Ind. Mus.*, XXXI, p. 186, footnote, 1929) have already pointed out that my choice of the name *Bhavania* was rather unfortunate, for a similar name had been used by Schmarda for a Polychaete *Bhawania* in *Neue Wirbellose Thiere*, I, ii, p. 164, 1861. The different spellings of the two names, however, permit of *Bhavania* being retained as a valid genus.

[2] Hora, *Rec. Ind. Mus.*, XIX, pp. 195-215 (1920).

examination, it was found that in this genus the snout is either broad and rounded, as in *Bhavania*, or long and pointed, as in the Tenasserim species of *Homaloptera*. The great variation in form and structure of the pectoral fins in different species of *Homaloptera* made me[1] abandon the genus *Bhavania*, unfortunately without a careful study of the poor material even then available from S. India.

In Mr. B. S. Bhimachar's collection there are four well preserved specimens of *Bhavania annandalei* from 35 to 83 mm. in length. They agree with my description, but I omitted to record in the original account that in *Bhavania* the gill-openings are small and are situated entirely above the base of the pectoral fins. This feature is of exceptional interest, for in no other genus of the Homalopterinae the gill-openings are restricted above the base of the pectoral fins. This feature alone is of sufficient merit to distinguish *Bhavania* from the rest of the Homalopterinae.

In the Gastromyzoninae,[2] however, the gill-openings are restricted in quite a number of genera -*Pseudogastromyzon*, *Sewellia*, *Beaufortia*, *Neogastromyzon* and *Gastromyzon*. It was indicated by me[3] that though the specialisation of form shows parallel evolution in the two subfamilies of the Homalopteridae, the modification of the gill-openings had not undergone similar changes in the two series, although they are used for the same purpose in a similar environment. The discovery of small gill-openings in *Bhavania* supplies a further proof of the parallelism in evolution, and shows that the causes that brought about this condition were probably the results of some divergent modifications in the original stock.

Nemachilus striatus Day.

1877. *Nemachilus striatus*, Day, *Fish. India*, p. 617, pl. cliii, fig. 8.

Mr. Bhimachar collected a fine series of 10 specimens of *Nemachilus striatus* from a rapid stream in a Coffee Plantation, Western Ghats. These specimens vary in length from 25—50 mm., while Day's largest specimen was 2½ inches. The form and colouration shown in Day's figure probably represent these features in an adult specimen. In the young individuals before me colouration varies considerably. In a specimen about 25 mm. in length there are only 8 vertical bands on the body, some of which show clear indications of splitting up vertically. These bands go on increasing in number and in a specimen about 50 mm. in length there are 12 bands. The bands in the anterior region become indistinct but the increase in their number continues behind the dorsal fin. According to Day the number of bands is from 12—16 in the part of the body behind the commencement of the dorsal fin.

One constant feature of colouration, to which Day makes no reference, is the presence at the base of the anterior dorsal rays of a jet black spot; this is very prominent in the young individuals.

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[1] Hora, *Rec. Ind. Mus.*, XXXIII, pp. 67-69 (1931); *Mem. Ind. Mus.*, XII, p. 274 (1932).

[2] Hora, *Mem. Ind. Mus.*, XII, p. 304 (1932).

[3] Hora. *Mem. Ind. Mus.*, XII, p. 326 (1932).

According to Day the lateral line passes direct from the centre of the orbit to the middle of the base of the caudal fin. In the specimens before me the lateral line is marked only for a short distance in the anterior region.

Both Day and Mr. B. S. Bhimachar collected specimens of *N. striatus* in association with *Bhavania annandalei.*

Nemachilus anguilla Annandale.

1919. *Nemachilus anguilla,* Annandale, *Rec. Ind. Mus.,* XVI, p. 127, pl. i, fig. 3 ; pl. iii, fig. 1.

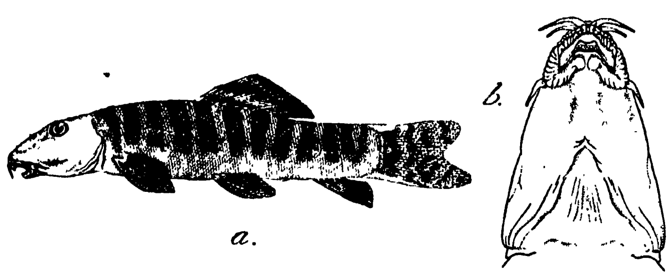
Nemachilus anguilla was described from 3 specimens collected in the Yenna River at Medha, Satara District, Bombay Presidency. Mr. Bhimachar obtained a young specimen, about 42 mm. in total length, from the Tunga River at Shimoga. This species can be readily distinguished by the presence of two short, stout, digitiform processes in front of the upper lip.

In the specimen under report the row of large, rectangular spots running along the mid-lateral line is more prominently marked.

Nemachilus bhimachari, sp. nov.

D. 2/12 ; A. 2/5 ; P. 11 ; V. 7 ; C. 18.

Nemachilus bhimachari is a stoutly built species in which the dorsal profile is moderately arched while the ventral profile is straight and horizontal throughout. The head is pointed ; its length is equal to the length of the caudal fin and is contained about 5 times in the total length of the fish. The width of the head is slightly greater than its height at the occiput which is about half the length of the head. The eyes are situated in the posterior half of the head and are placed dorso-laterally ; they are not visible from the ventral surface and are one



TEXT-FIG. 5.—*Nemachilus bhimachari,* sp. nov.
a. Lateral view of type-specimen Nat. Size. *b.* Ventral surface of head of same. ×2½.

diameter apart. The diameter of the eye is contained about 5 times in the length of the head and 2·5 times in the length of the snout. The mouth opening is small, crescentic and horizontal. The lips are fleshy and fimbriated ; they are continuous at the angles of the mouth, but the lower lip is interrupted in the middle. The lips do not cover the anterior portion of the jaws which are sharp and horny. The upper jaw is produced into a beak-like process in the middle while the lower jaw has a broad, rasping edge. The barbels are small ; the inner rostrals

and maxillaries are subequal and are as long as the diameter of the eye while the outer rostrals are considerably shorter. The gill-openings are mostly lateral and extend to just below the base of the pectoral fin.

The depth of the body is contained about 6·5 times in the total length of the fish. The caudal peduncle is considerably higher than long. The body is covered throughout with small distinct scales which are somewhat faintly marked on the ventral surface. The lateral line is distinctly marked up to the base of the anal fin. There are small fleshy appendages at the bases of the paired fins.

The dorsal fin commences considerably in advance of the ventrals and its commencement is equally distant from the tip of the snout and the base of the caudal fin; its base is slightly shorter than the head and its upper border is truncate. The longest ray of the dorsal is not as high as the depth of the body below it. The pectoral fin is pointed in the middle; its length equals the head in front of the posterior margin of the orbit; it is separated from the ventral by a distance equal to about half of its length. The ventral fin is almost as long as the pectoral and is similarly pointed in the middle; it just misses the anal opening. The anal fin, when laid flat, reaches the base of the caudal fin which is emarginate with rounded lobes; the lower lobe is longer than the upper.

The colouration is very characteristic of the species. There are about a dozen black bands which are vertical in the posterior region and obliquely directed forward in the anterior region; these bands are wider than the pale-olivaceous interspaces between them. The dorsal fin is marked with three broad bands, the outermost forms a black edge to the fin. The caudal fin is marked with a number of incomplete bands. A black streak runs from the eye to the tip of the snout.

Locality.—Tunga River at Shimoga (December, 1935).

Type-specimen.—F12178/1, *Zoological Survey of India* (*Ind. Mus.*), *Calcutta.*

Remarks.—*Nemachilus bhimachari* represents an intermediate form between *Nemachilus* and *Nemachilichthys*, and it seems questionable whether the latter genus, which is distinguished from the former by the length of its dorsal fin and the elongated snout, is really distinct from *Nemachilus*. Attention may here be directed to the fact that in several species of *Barbus*, such as *B. curmuca*, *B. dobsoni*, *B. kolus*, etc., occurring in the Western Ghats and the hill ranges of the Peninsula the snout is also somewhat cylindrical and elongated.

In its general facies *N. bhimachari* is abundantly distinct from all other species of *Nemachilus* known from India; its most salient features are (i) elongated snout, (ii) fimbriated lips, (iii) oblique, vertical bands; (iv) colouration of dorsal and caudal fins and (v) form of caudal fin.

Glyptothorax dekkanensis (Günther).

1923. *Glyptothorax dekkanensis*, Hora, *Rec. Ind. Mus.*, XXV, p. 24, text-fig. 3

In Mr. Bhimachar's collection there is a fine example of *Glyptothorax dekkanensis*, about 140 mm. in total length. The specimen agrees with Günther's description and my observations on this species.

The body is covered with small, longitudinally arranged tubercles of unequal size; those along the lateral line are of a somewhat larger size and form a regular series. These tubercles are absent along the dorsal surface, at the base of the dorsal fin and on the head.

TWO ABNORMAL SPECIMENS OF *Ophicephalus* spp.

The absence of the ventral fins is a fairly common abnormality in the members of the genus *Ophicephalus* but amongst Indian species such a condition is usually associated with *O. gachua*.[1] Mr. B. S. Bhimachar has sent an undoubted specimen of *O. punctatus* Bloch, about 169 mm. in total length, in which both the ventral fins are wanting. Unfortunately there is an incision in the mid-ventral line, but, so far as can be ascertained, there does not seem to be any abnormality in lepidosis in the region of the ventral fins. In all other respects the specimen is quite normal.

Of unusual interest is the abnormal condition of the dorsal fin in a young specimen of *O. gachua* Ham., 93 mm. in total length. The dorsal fin is divided into two portions, the anterior smaller, consisting of 2 or 3 rays and commencing about the 6th scale behind the upper angle of the gill-opening. This portion is separated from the normal fin by a distance almost equal to twice the diameter of the eye and the intervening space is covered by about 5 scales. In other respects the specimen is quite normal.

2. DR. H. S. RAO'S COLLECTION FROM THE MYSORE STATE.

In November-December 1928, Dr. H. S. Rao of the Zoological Survey of India collected fishes in the Shimoga and Kadur Districts of the Mysore State. I give below a short description of the localities based on Dr. Rao's notes, with lists of species collected therefrom:

Sharavati River below the Jog Falls, 2 miles below the Mysore Bungalow. 26.xi.1928.

"The stream is over 500 feet below the point at which the falls begin and is strewn with huge granite boulders. In the course of the stream there are shallow pools with sandy bottom."

1. *Barbus* sp. (Large-scaled Barbel) . . . . . 1 specimen.
2. *Barbus filamentosus* (C. & V.) . . . . . 1 specimen.

A hill-stream on the Jog-Sagar Road near the junction of the road leading to the ferry. 30.xi.1928.

"Bed strewn with large stones and boulders; in places with gravel."

1. *Brachydanio rerio* (Ham.) . . . . . . 1 specimen.
2. *Panchax lineatus* C. & V. . . . . . . 1 specimen.

[1] Hora & Mukerji, *Rec. Ind. Mus.*, XXXVI, p. 137 (1934).

Stream north of Sagar Rest House, Shimoga Dist. 1-2.xii.1928.

" Full of weeds and algae. Bed sandy in some parts, gravelly in others."

1. *Mastacembelus armatus* (Lacép.) . . . . . 1 specimen.
2. *Garra jerdoni* (Day) . . . . 1 specimen.
3. *Barbus ticto* (*Ham.*) . . . . 55 specimens.
4. *Rasbora daniconius* (Ham.) . . . . . . 11 specimens.
5. *Danio strigillifer* Myers . . . . . 1 specimen.
6. *Brachydanio rerio* (Ham.) . . . . . . 87 specimens.
7. *Nemachilus denisonii* Day . . . . . . 1 specimen.
8. *Nemachilus sinuatus* Day . . . . . . 1 specimen.
9. *Lepidocephalichthys thermalis* (C. & V.) . . . . 72 specimens.
10. *Panchax lineatus* C. & V. . . . . . . 14 specimens.
11. *Macropodus cupanus* (C. & V.) . . . . . 30 specimens.
12. *Ophicephalus gachua* Ham. . . . . . 2 specimens.

Streams and pools on the Kalurkatte Road near Sagar, Shimoga Dist. 3.xii.1928.

" Bottom covered with gravel in some parts and with sand and mud in other parts."

1. *Barbus ticto* (Ham.) . . . . 7 specimens.
2. *Barbus vittatus* Day . . . . 2 specimens.
3. *Barbus cosuatus* (Ham.) . . . . . . 1 specimen.
4. *Rasbora daniconius* (Ham.) . . . . . . 1 specimen.
5. *Esomus barbatus* (Jerdon). 2 specimens.
6. *Brachydanio rerio* (Ham.) . . . . . . 59 specimens.
7. *Lepidocephalichthys thermalis* (C. & V.) . . . . 3 specimens.
8. *Panchax lineatus* C. & V. . . . . . . 52 specimens.
9. *Macropodus cupanus* (C. & V.) . . . . . 19 specimens.

Tank near Sagar Rest House, Shimoga Dist. 3-5.xii.1928.

" Surface covered with abundant growth of aquatic vegetation."

1. *Rasbora daniconius* (Ham.) . . . . . . 4 specimens.
2. *Panchax lineatus* C. & V. . . . . . . 23 specimens.
3. *Macropodus cupanus* (C. & V.) . . . . . 4 specimens.

Stream near Kugve, 4 miles west of Sagar, Shimoga Dist. 4.xii.1928.

" Muddy with lot of vegetation."

1. *Mastacembelus armatus* (Lacép.) . . . . 1 specimen.
2. *Barbus dorsalis* (Jerdon) . . . . . . 4 specimens.
3. *Rasbora daniconius* (Ham.) . . . . . . 4 specimens.
4. *Esomus barbatus* (Jerdon) . . . . . . 1 specimen.
5. *Ophicephalus gachua* Ham. . . . . . 4 specimens.

Streams on the Sagar-Shimoga Road, Shimoga Dist. 5.xii.1928.

1. *Garra jerdoni* (Day) . . . . 2 specimens.
2. *Rasbora daniconius* (Ham.) . . . . . . 1 specimen.
3. *Labauca atpar* (Ham.) . . . . . . 3 specimens.
4. *Nemachilus denisonii* Day . . . . . . 2 specimens.

Tunga River at Shimoga. 8-10.xii.1928.

" Rocky in the middle, sandy or full of gravel near the banks. Mostly shallow, but with deep pools in the middle. Small, sandy pools near the bank overgrown with weeds."

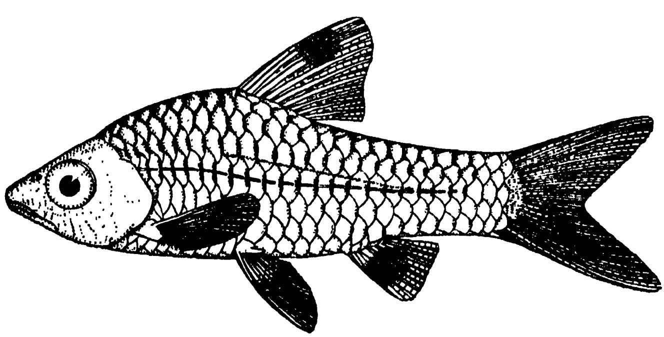
1.	*Garra jerdoni* (Day)	2 specimens.
2.	*Barbus pinnauratus* (Day)	2 specimens.
3.	*Barbus sophore* (Ham.)	7 specimens.
4.	*Barbus dorsalis* (Jerdon)	2 specimens.
5.	*Barbus pulchellus* (Day)	1 specimen.
6.	*Cirrhina fulungee* (Sykes)	2 specimens.
7.	*Rasbora daniconius* (Ham.)	8 specimens.
8.	*Esomus barbatus* (Jerdon)	3 specimens.
9.	*Rohtee duvaucelli* (C. & V.)	1 specimen.
10.	*Labauca atpar* (Ham.)	1 specimen.
11.	*Nemachilichthys shimogensis* Rao.	1 specimen.
12.	*Mystus carasius* (Ham.)	11 specimens.
13.	*Ophicephalus punctatus* Bloch.	1 specimen.
14.	*Ambassis ranga* (Ham.)	1 specimen.

Bhadra River at Bhadravati, Shimoga Dist. 12-14.xii.1928.

" Bottom rocky in places but mostly covered with thick layer of silt. At the sides the bed consists of large gravel or coarse sand. Vegetation rather scanty, except for small shrubs in sandy part. Filamentous and other algae in abundance."

1.	*Barbus dorsalis* (Jerdon)	2 specimens.
2.	*Barbus ticto* (Ham.)	13 specimens.
3.	*Rasbora daniconius* (Ham.)	20 specimens.
4.	*Esomus barbatus* (Jerdon)	28 specimens.
5.	*Danio strigillifer* Myers	1 specimen.
6.	*Labauca atpar* (Ham.)	43 specimens.
7.	*Lepidocephalichthys thermalis* (C. & V.)	15 specimens.
8.	*Panchax lineatus* C. & V.	15 specimens.
9.	*Macropodus cupanus* (C. & V.)	3 specimens.

From the description of the localities it is clear that Dr. Rao collected fishes from pools and puddles and, in consequence, the fish-association in this lot mostly consists of small, surface-living or mud-living species. Only a few rapid-water forms are present and the larger species are represented by young specimens only.



TEXT-FIG. 6.—Lateral view of a specimen of *Barbus cosualus* (Ham.), to show the colour spots on the dorsal and anal fins and sensory folds on the head. $\times 3\frac{2}{3}$.

Most of the species represented in this lot do not call for any comments, but attention may here be directed to the presence of an apodal

specimen of *Ophicephalus gachua*, 63 mm. in total length, and of specimens of *Danio strigillifer* Myers. In the specimen of *Barbus cosuatus* the lateral line is only absent on the last 3 or 4 scales and the black bands on the dorsal and anal fins are represented by well defined patches which become diffuse on the neighbouring rays. The most remarkable feature of this species appears to be the presence of numerous, fine, parallel sensory folds on the sides of the head. This feature it shares with the fishes of the genus *Cyclocheilichthys* Bleeker, but in other respects it is quite different.

3. PROFESSOR C. R. NARAYAN RAO'S COLLECTION FROM THE CAUVERY RIVER IN THE COORG STATE.

Professor C. R. Narayan Rao of the Central College, Bangalore (University of Mysore) has presented to the Zoological Survey of India 211 specimens of fish collected over 10 years ago from the headwaters of the Cauvery River in the Coorg State. Unfortunately the locality labels have been destroyed by the formalin solution in which the specimens had been kept, and the collection also has suffered considerably by a long immersion in this fluid.

Professor Narayan Rao informs me that the fish were collected at 4 places along the Cauvery River—Bhagamandla, Siddapur, Fraserpet, and Dubari. Of these places he writes :-

" The Cauvery takes its source in Bhagamandla where it is a narrow stream with even current of water flowing over soft earth—mostly loamy soil. At Siddapur the stream is still slender and sluggish and there is not much difference in the character of the soil. At Dubari, the river widens out into a fast stream flowing over small boulders and sand. It is still wider at Fraserpet but the current is slow, flowing over a sandy bed."

Of the 54 species represented in this collection, 33 belong to the Cyprinidae, 11 to the Siluroidea (families : Heteropneustidae, Bagridae, Sisoridae, Schilbeidae, and Clariidae), 1 to the Mastacembelidae, 2 to the Cyprinodontidae, 1 to the Xenentodontidae, 3 to the Ophicephalidae, 1 to the Osphronemidae, 1 to the Ambassidae and 1 to the Gobiidae. The fish association fully bears out the nature of the localities as described in Professor Narayan Rao's note ; most of the species are sluggish-water forms.

Besides the two new species of *Barbus*, which belong to the group *Puntius*, there are representatives of several rare forms. Special mention may be made of the fact that *B. filamentosus* and *B. mahecola* are definitely proved to be conspecific, the former represents male individuals and the latter either young or female specimens. *Rasbora caverii* (Jerdon) is redescribed from a large number of specimens ; this species was imperfectly known and had not been recognised as distinct from *B. daniconius*. The precise generic and specific limits of *Pseudeutropius taakree* (Sykes) will be discussed elsewhere.

The following is a complete list of the species represented in Professor Narayan Rao's collection. Most of the forms do not call for any

comments, but the two new species are described below and notes are added on *Barbus filamentosus* and *Rasbora caverii*.

		No. of specimens.
	MASTACEMBELIDAE.	
1.	*Mastacembelus armatus* (Lacép.)	2
	CYPRINIDAE.	
2.	*Carassius vulgaris* Nilsson	1
3.	*Garra mullya* (Sykes)	8
4.	*Garra jerdonii* Day	1
5.	*Garra stenorhynchus* (Jerdon)	2
6.	*Labeo bogut* (Sykes)	3
7.	*Labeo dussumieri* (C. & V.)	3
8.	*Barbus chrysopoma* C. & V.	3
9.	*Barbus pinnauratus* Day	7
10.	*Barbus dubius* Day	1
11.	*Barbus micropogon* C. & V.	2
12.	*Barbus cauveriensis*, sp. nov.	2
13.	*Barbus sophore* (Ham.)	5
14.	*Barbus lithopidos* Day	2
15.	*Barbus dorsalis* (Jerdon)	17
16.	*Barbus kolus* Sykes	2
17.	*Barbus filamentosus* (C. & V.)	2
18.	*Barbus ticto* (Ham.)	1
19.	*Barbus melanampyx* Day	1
20.	*Barbus narayani*, sp. nov.	2
21.	*Cirrhina fulungee* (Sykes)	1
22.	*Cirrhina reba* (Ham.)	2
23.	*Scaphiodon thomasii* (Day)	1
24.	*Aspidoparia morar* (Ham.)	1
25.	*Rohtee ogilbii* Sykes	1
26.	*Rohtee neilli* Day	2
27.	*Amblypharyngodon microlepis* (Bleeker)	4
28.	*Rasbora daniconius* (Ham.)	3
29.	*Rasbora caverii* (Jerdon)	21
30.	*Esomus barbatus* (Jerdon)	1
31.	*Danio malabaricus* (Jerdon)	8
32.	*Barilius gatensis* (C. & V.)	7
33.	*Nemachilus denisonii* Day	9
34.	*Nemachilus dayi* Hora	3
	HETEROPNEUSTIDAE.	
35.	*Heteropneustes fossilis* (Bloch)	12
	BAGRIDAE.	
36.	*Mystus aor* (Ham.)	2
37.	*Mystus punctatus* (Jerdon)	1
38.	*Mystus cavasius* (Ham.)	10
39.	*Mystus vittatus* (Bloch)	12
40.	*Mystus montanus* (Jerdon)	9
41.	*Mystus malabaricus* (Jerdon)	4
	SISORIDAE.	
42.	*Nangra viridescens* (Ham.)	1
43.	*Glyptothorax madraspatanus* (Day)	1

	No. of specimens.
SCHILBEIDAE.	
44. *Pseudeutropius taakree* (Sykes)	1
CLARIIDAE.	
45. *Clarias batrachus* (Linn.)	2
CYPRINODONTIDAE.	
46. *Panchax blochii* (Arnold)	5
47. *Panchax lineatus* C. & V.	1
XENENTODONTIDAE.	
48. *Xenentodon cancila* (Ham.)	4
OPHICEPHALIDAE.	
49. *Ophicephalus marulius* Bloch.	1
50. *Ophicephalus punctatus* Bloch.	2
51. *Ophicephalus gachua* Ham.	4
OSPHRONEMIDAE.	
52. *Macropodus cupanus* (C. & V.)	2
AMBASSIDAE.	
53. *Ambassis ranga* (Ham.)	2
GOBIIDAE.	
54. *Glossogobius giuris* (Ham.)	3

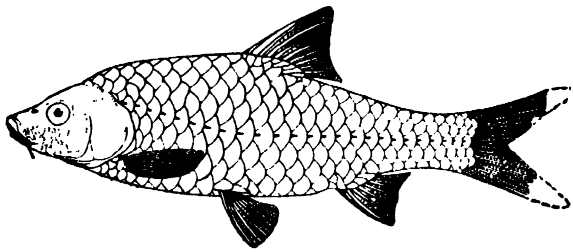
Barbus cauveriensis, sp. nov.

D. 3/8-9 ; A. 2/5-6 ; P. 15-16 ; V. 7 ; C. 18.

In *Barbus cauveriensis* the dorsal profile of the head rises sharply from the tip of the snout to the occiput and thereafter gently to the dorsal fin beyond which it gradually slopes down to the base of the caudal fin. The ventral profile is evenly arched throughout. The head is somewhat pointed and the snout considerably produced. In these respects the species corresponds very closely with forms like *B. dubius*, *B. thomassi*, *B. curmuca* and *B. kolus*, all of which are found in South India.

In the two specimens before me the head is proportionately larger in the smaller individual ; it is contained from 3·6 to 3·8 times in the length without the caudal, its width is contained 1·7 times and its height at occiput 1·4 times in its length. The greatest depth of the body is contained from 2·8 to 3·2 times in the length without the caudal ; the body is considerably deeper in the smaller specimen and is almost as thick as the width of the head. The eyes are small and situated almost entirely in the anterior half of the head ; the diameter of the eye is contained from 4·6 to 4·8 times in the length of the head, 1·6 times in the length of the snout and from 1·6 to 1·8 times in the interorbital width. The mouth is small, somewhat oblique, sub-inferior and horse-shoe-shaped ; the maxilla does not extend to the anterior border of the orbit ; the lips are thick, somewhat papillated, and continuous. The post-labial groove is interrupted in the middle. There is a pair of small maxillary barbels which are as long as the diameter of the eye. On the sides of the head there are numerous, fine, parallel sensory folds similar

to those present in fishes of the genus *Cyclocheilichthys* Bleeker. The suborbital ring of bones is narrow.



TEXT-FIG. 7.—Lateral view of the type-specimen of *Barbus cauveriensis*, sp. nov. × ½.

The scales are large and firmly fixed ; there are from 25 to 26 scales along the lateral line and 9 longitudinal series between the bases of the dorsal and ventral fins. Between the lateral line and the base of the ventral fin there are 3½ rows of scales. The number of scales round the caudal peduncle is 12 and in front of the dorsal fin 9. The scales at the base of the dorsal fin form a tile-like row. The lateral line is complete. The caudal peduncle is from 1·3 to 1·4 times as long as high.

The dorsal fin commences almost midway between the tip of the snout and the base of the caudal fin ; its free border is slightly concave. The dorsal spine is osseous and smooth ; it is three-fourths of the length of the head. The pectorals are considerably shorter than the head and do not extend to the bases of the ventrals which are separated from the anal-opening by a distance almost equal to half of their length. The body between the ventrals and the anal is somewhat keeled. The anal fin is short and is separated from the caudal by a considerable distance. The caudal fin is deeply forked.

The specimens under report are greyish brown, but on account of long immersion in a formalin solution appear to have lost all natural colour.

Locality.—Cauvery River, Coorg State.

Type-specimen.—F 12179/1, *Zoological Survey of India* (*Ind. Mus.*), *Calcutta.*

Remarks.—This is a remarkable species of the genus *Barbus* and can be distinguished by (i) two barbels, (ii) osseous, smooth spine, (iii) large scales, (iv) small eyes, (v) greatly produced snout, (vi) nature of dorsal profile, and (vii) sensory folds on the head. I am not aware of any other species of the genus *Barbus* in any way closely allied to this species, unless any of Jerdon's species, which are very little known, may prove to be this form.

Measurements in millimetres.

Total length without caudal	105·0	124·0
Length of head	28·9	32·5
Width of head	17·0	19·0
Height of head at occiput	20·0	22·5
Depth of body	37·0	39·0
Width of body	16·0	19·0
Diameter of eye	6·0	7·0
Interorbital width	11·0	11·3

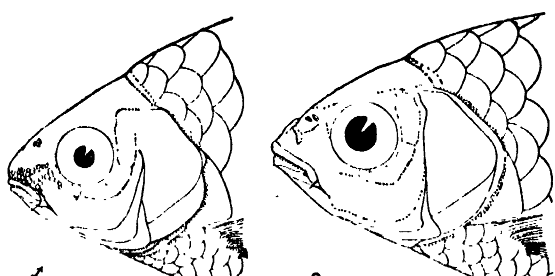
Length of snout	10·0	11·0
Length of dorsal spine	22·0	24·0
Longest ray of anal	14·0	16·5
Length of pectoral	21·0	22·5
Length of caudal peduncle	18·0	22·0
Least height of caudal peduncle	14·0	15·2

Barbus filamentosus (Cuv. & Val.).

1844. *Leuciscus filamentosus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XVII, p. 96, pl. cccxcii.

Of the very large number of species of the genus *Barbus* (*s. l.*) known from India, *B. filamentosus* can be readily distinguished by its large scales and characteristic colouration. Identically the same features distinguish *B. mahecola* (C. & V.).[1] In his account of the former species Day[2] stated that " It is so similar to *B. Mahecola* (except in wanting barbels) that I have not figured it." When considering the utility of barbels in separating species of *Barbus* Day (*op. cit.*, p. 556) remarked :

" It is remarkable how very similar the *Barbus Mahicola*, C. V. which has two barbels, is to the *B. filamentosus*, C. V. with none. If a number of examples are examined it will be found that in some these appendages are very minute, the barbels being, as a rule, smallest in specimens obtained furthest from the hills. In South Canara, the Wynaad, and base of the Neilgherries, where the barbels are large, the *B. Mahicola* abounds : towards Cochin and up the Coromandel coast as far as Madras they are small or absent, and *B. filamentosus* is the type. Here, undoubtedly, the question must force itself on one's notice, are we dealing with two distinct species, or one in a state of transition ? If the latter, which is the original form ?"



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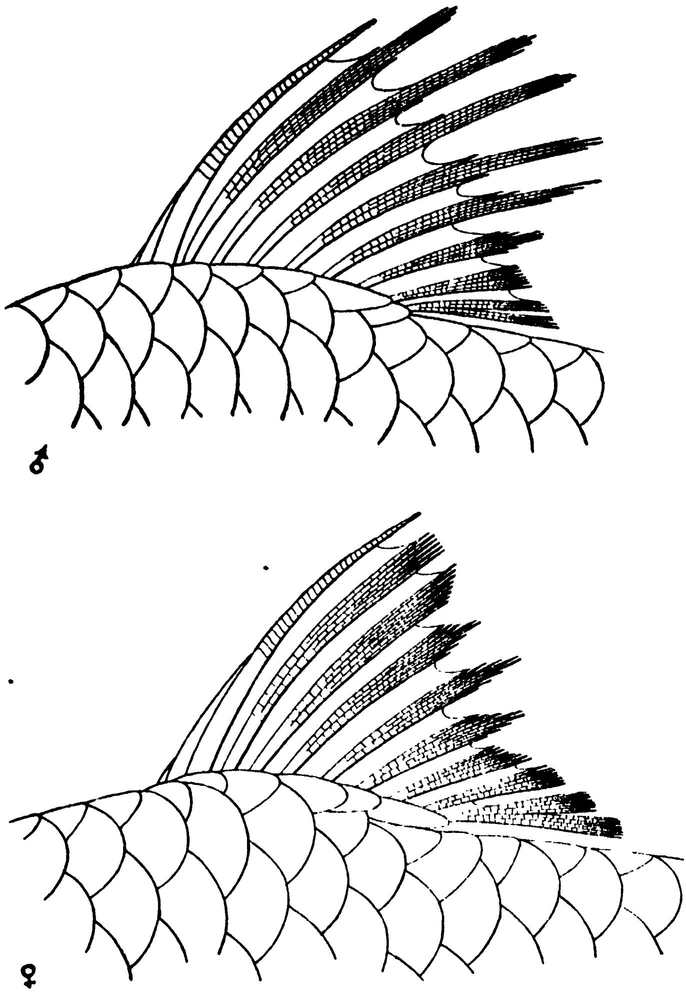
TEXT-FIG. 8.—Lateral view of head and anterior part of body of a male and a female specimen of *Barbus filamentosus* (C. & V.). Nat. Size.

In his " Fishes of Malabar " Day had considered *Puntius filamentosus* as the adult of *P. mahecola*, but Günther[3] did not agree with his view and remarked, " I hesitate to adopt this opinion, because the black caudal spot is more advanced in *B. filamentosus* than in the figure of *L. mahecola*." From an examination of the material in the collection of

[1] Cuvier & Valenciennes, *Hist. Nat. Poiss.*, XVII, p. 305. pl. 502 (1842).
[2] Day, *Fish. India*, pp. 582, 556 (1877).
[3] Günther, *Cat. Fish. Brit. Mus.*, VII, p. 146 (1868).

the Indian Museum I am convinced that Day was fully justified in his views regarding the identity of the two species referred to above. In



TEXT-FIG. 9.—Lateral view of dorsal fin of a male and a female specimen of *Barbus filamentosus* (C. & V.). $\times 1\frac{2}{3}$.

the adult condition, especially at breeding time, secondary sexual characters appear so that in the males the anterior 4 or 5 branched rays of the dorsal fin are prolonged and the snout is covered by a patch of large tubercles on either side in front of the eyes. The male in this condition represents the *filamentosus*-type and the female *mahecola*-type. It was pointed out by Mukerji and myself[1] that more or less similar sexual differences were responsible for *Barbus chagunio* and *B. spilopholus* being recognised as two distinct species. Quite recently Misra and I[2]

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[1] Hora & Mukerji, *Journ. As. Soc. Bengal* (N. S.) XXVII 1931, p. 137 (1933).
[2] Hora & Misra, *Rec. Ind. Mus.*, XXXVIII, p. 341 (1936).

described the sexual differences in *Labeo dero*. From the above it is abundantly clear that *B. filamentosus* and *B. mahecola* cannot be regarded as distinct species; the former name has page priority over the latter.

Attention may here be directed to the fact that Jerdon[1] described this species under three names—*Systomus filamentosus*, *S. assimilis* and *S. madraspatensis*, and the descriptions show that he must have had specimens of different sizes and sexes before him. He also included *Leuciscus mahecola* in his list but had no specimen of the species for examination. Day[2] also described the young of this species as *Puntius* (*Capoeta*) *lepidus*, but in his "Fishes of India" he included it in the synonymy of *Barbus mahecola*. Sundara Raj[3] in his account of the freshwater fish of Madras listed both the species but remarked as follows under *B. filamentosus*:

"It is very doubtful if the present species is really distinct from *B. mahecola* (C. & V.). Both forms, those with a pair of minute maxillary barbels (*B. mahecola*) and those without them (*B. filamentosus*), occur in Madras and are identical in all other respects."

I have found minute barbels even in the specimens referred by Day to *mahecola*. On account of their small size, however, they are liable to be overlooked sometimes.

Barbus narayani, sp. nov.

D. 3/9; A. 3/6; P. 14; V. 9; C. 18.

Barbus narayani is a small, well-built species in which both the dorsal and the ventral profiles are greatly arched, the former more so than the latter. The head is short and blunt; its length is contained about 4 times in the total length without the caudal. The head is almost as high at the occiput as its length, while its width is about two-thirds of the length. The depth of the body is contained about 2·5 times in the length without the caudal while its width is somewhat less than that of the head. The eyes are large and are situated considerably nearer to the tip of the snout than to the posterior border of the operculum. The diameter of the eye is contained about 2·9 times in the length of the head. The snout is shorter than the diameter of the eye while the interorbital width is almost equal to it. The mouth is small and somewhat oblique. The lips are fleshy and continuous; they are studded with minute spines. The labial groove is interrupted in the middle. The barbels are totally absent.

The scales are well developed; there are about 22 scales along the lateral line and 9 rows between the bases of the dorsal and ventral fins, 4 rows above the lateral line and 4 rows below it. There are 12 scales round the caudal peduncle and 8 before the dorsal fin. The caudal peduncle is almost as high as long.

The dorsal fin commences slightly in advance of the ventral; its commencement is nearer the tip of the snout than the base of the caudal. It possesses a feeble and articulated spine which is considerably longer

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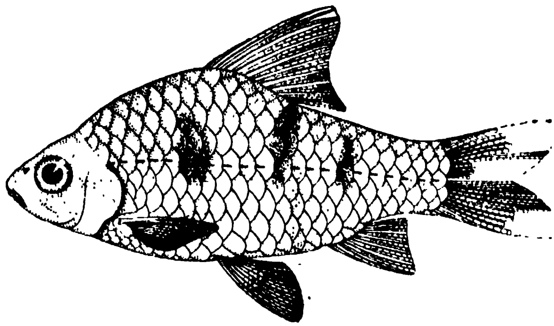
[1] Jerdon, *Madras Journ. Lit. Sci.*, XV, pp. 318, 319, 322 (1848).
[2] Day, *Proc. Zool. Soc. London*, p. 196 (1868).
[3] Sundara Raj, *Rec. Ind. Mus.*, XII, p. 258 (1916).

than the head; its free border is slightly concave though rounded at the top. The pectoral fin is slightly shorter than the head, but it extends



TEXT-FIG. 10.—Lateral view of the type-specimen of *Barbus narayani*, sp. nov. ×1½.

to the commencement of the ventral fin which is as long as the pectoral. The ventrals just reach the anal-opening. The anal fin is short. The caudal fin is forked.

Due to a long immersion in a formalin solution the original colour has disappeared in the specimens before me; the general colour at present is greyish-brown. Three vertical black marks on the body are faintly indicated, the first below the commencement of the dorsal, the second below or just behind the dorsal and the third above the posterior half of the anal.

Locality.—Cauvery River, Coorg State.

Type-specimen.—F 12180/1, *Zoological Survey of India* (*Ind. Mus.*), *Calcutta.*

Remarks.—This small species may be distinguished by the following combination of characters: (i) absence of barbels, (ii) smooth, articulated dorsal ray longer than the head, (iii) complete lateral line; (iv) 22 scales along lateral line and 9 rows between the bases of dorsal and ventral fins, and (v) three vertical marks on the body.

I have great pleasure in associating the name of this species with that of Professor C. R. Narayan Rao through whose generosity the Zoological Survey has received a valuable collection from the Cauvery River.

Measurements in millimetres.

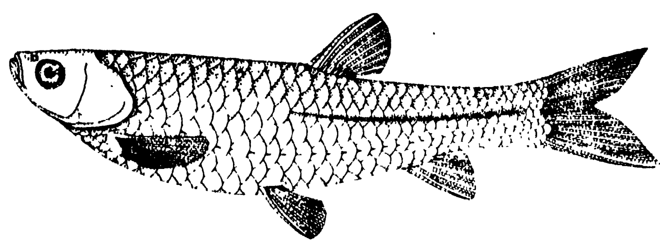
Total length without caudal	46·0	47·0
Length of head	11·5	11·5
Width of head	8·0	8·0
Height of head at occiput	11·3	11·4
Depth of body	18·0	19·0
Width of body	7·0	7·0
Diameter of eye	4·0	4·0
Interorbital width	4·0	4·3
Length of snout	3·6	3·6
Length of dorsal spine	13·5	13·6
Longest ray of anal	9·0	9·0
Length of pectoral	11·0	11·0
Length of caudal peduncle	8·0	8·0
Least height of caudal peduncle	7·5	7·6

Rasbora caverii (Jerdon).

1848. *Leuciscus Caverii*, Jerdon, *Madras Journ. Lit. & Sci.*, XV, p. 320.

Jerdon's *Leuciscus caverii* has not been recognised as a distinct species both by Günther[1] and Day[2], the former listed it among the species insufficiently described for their systematic position to be ascertained from the accounts given, while Day included it in the synonymy of *Rasbora daniconius* (Ham.) without any comments. In Professor C. R. Narayan Rao's collection there are 21 specimens of a species of *Rasbora*, which are abundantly distinct from *R. daniconius* and *R. rasbora*, and seem to agree with the meagre and inadequate description of *Leuciscus caverii*, which, according to Jerdon, is very common in the Cauvery and all its branches. Jerdon's description of *L. caverii* is as follows :—

"Head about one-fourth length of body; height one-fifth of length; eye nearly one-fifth of length of head; dorsal placed a little behind the middle of back, nearly opposite to anal; 30 scales along the side in 7 rows—D. 9, A. 6—green above, silvery beneath; cheeks golden; a blue stripe from operculum to tail, with a narrow yellow one above it; lateral line concave—usually about 3 inches long."



TEXT-FIG. 11.—Lateral view of an adult specimen of *Rasbora caverii* (Jerdon). Approximately natural size.

The above description agrees more particularly with the smaller individuals before me, while the proportions, etc., of the adult specimens are quite different. Jerdon also noted that—

"I possess a sketch of another *Leuciscus* from the Cauvery of which I have lost my specimen, which appears to differ from any of these. It is nearly allied to *L. Caverii* in form, but has a much larger eye, and the depression in the crown more marked, muzzle in front of the depression continuing straight, parallel with the back; profile of abdomen good deal arched; lateral line much curved. I am unable to give the number of rays or scales."

In the case of Jerdon it is known that he very often recognised the young and adult specimens of a fish as distinct species and the above two descriptions seem to refer to the different stages of growth of the same species. The description of the dorsal and the ventral profiles as also of the lateral line agree with the same features in the adult specimens before me.

As to the precise systematic position of Jerdon's *Leuciscus malabaricus*, and *L. flavus*, which Day included in the synonymy of *Rasbora daniconius* along with *L. caverii*, it is very difficult to express an opinion without examining fresh material from the type-localities.

[1] Günther, *Cat. Fish. Brit. Mus.*, VII, p. 5 (1868).
[2] Day, *Fish. India*, p. 584 (1877).

Rasbora caverii may now be redescribed as follows :—

D. 2/7 ; A. 1/5 ; P. 14 ; V. 7 ; C. 19.

In the adult specimens the dorsal profile is almost straight and horizontal while the ventral profile is greatly arched. In the young individuals, however, both the dorsal and the ventral profiles are only slightly arched. The head is bluntly pointed ; it is relatively large in young individuals, its length being contained from 5·1 to 5·6 times in the total length and from 4·2 to 4·6 times in the length without the caudal. The width and height of head increase with growth, the former is contained from 1·9 to 2·6 times and the latter from 1·4 to 1·8 times in the length of the head. The depth of the body is contained about 5 times in the total length and from 3·9 to 4·2 times in the length without the caudal. The eye is situated entirely in the anterior half of the head ; its diameter is contained from 3·5 to 3·6 times in the length of the head. The snout is somewhat shorter than the diameter of the eye. The interorbital space is narrower in the young individuals, being less than the diameter of the eye. In adults the space between the orbits is flat and about 1⅓ times the diameter of the eye. The mouth is small and obliquely directed upwards ; the maxilla does not extend to below the anterior margin of the orbit. The lower jaw bears a prominent knob in the middle and there is a corresponding emargination in the upper jaw. The lips are moderately fleshy and continuous ; the post-labial groove is interrupted in the middle. The pharyngeal teeth are curved and sharp ; they are situated in 3 rows : 4, 3, 2. The barbels are totally absent. The gill-membrane is well developed.

The scales are thin but firmly adherent ; their exposed portions are marked with a large number of radii. The lateral line is complete and curved ; there are about 32 perforated scales. The number of scales from the upper angle of the gill-opening to the base of the caudal is about 36-37. There are 7 series of scales between the bases of the dorsal and ventral fins and 1½ to 2 between the lateral line and the base of the ventral fin. The number of predorsal scales is 16-17, while there are 14 scales round the caudal peduncle, which is almost twice as long as high. There is a scaly appendage in the axil of the ventral fin.

The dorsal fin commences considerably behind the commencement of the ventral but does not extend over the anal fin. Its longest ray is equal to the head behind the middle of the eyes, and its free border is rounded ; its commencement is considerably nearer to the base of the caudal than to the tip of the snout. The pectorals are small and do not extend to the ventrals, which are separated from the anal-opening by a distance equal to three-fourths of their own length. The anal fin is small and commences midway between the base of the caudal and the commencement of the ventrals. The caudal fin is forked with both the lobes pointed ; the lower lobe is longer and better developed than the upper.

The general colour of the spirit specimens before me is olivaceous with a faintly marked lateral streak on the sides ; this lateral band is more prominent in the posterior half of the body.

Locality.—Cauvery River, Coorg State.

Measurements in millimetres.

Total length excluding caudal	54·0	71·0	79·0
Length of caudal	12·0	20·0	17·0
Length of head	13·0	16·5	17·0
Width of head	5·0	7·5	8·8
Height of head at occiput	7·2	10·8	11·5
Depth of body	13·0	18·0	19·0
Width of body	6·0	8·6	10·0
Diameter of eye	3·7	4·5	4·7
Length of snout	3·3	4·4	4·3
Interorbital width	3·0	5·7	5·8
Longest rays of dorsal	9·8	14·0	12·0
Longest ray of anal	9·2	11·0	11·0
Length of pectoral	9·8	13·0	13·0
Length of ventral	8·0	11·0	11·8
Length of caudal peduncle	13·0	15·0	19·0
Least height of caudal peduncle	7·0	8·0	9·0

DESCRIPTIONS OF THREE NEW HYDROPHILIDAE FROM INDIA.

By A. D'ORCHYMONT, *Brussels*.

Helochares (Agraphydrus) exedis, sp. nov.

Type : No. $\frac{3802}{H4}$. In the Zoological Survey of India (Indian Museum), Calcutta. Bombay Presidency, Poona District, Khandala, alt. *ca.* 2,500 feet ; 6-10.iii.1918 ; among damp algae on cliff at edge of waterfall (Annandale), ♂, 2×1 mm.

Paratypes : Nos. $\frac{3803\text{-}3805}{H4}$. Same locality ; same collector ; a few specimens.

Distinguished from all previously described *Agraphydrus* by its unpolished, somewhat eroded, nearly unpunctate upper surface. Under a very high power, however, it is possible to detect very fine and small punctures, separated from one another by about five times their diameter. The eroded appearance of the upper surface (head. prothorax, scutellum and wing cases) is due to an extremely fine, microscopical reticulation, which is difficult to see even under the microscope.

Of an obscure testaceous colour, obscured on the labrum, middle of forehead, between the eyes faint and indefinite in places, apparently owing to transparency, upon the disc of prothorax, very faintly on the disc of elytra. On the head the Y-suture is blackish with a row of coarser punctures behind the anterior branches of the Y. Eyes small. Antennae 9-jointed, joints 4 and 5 very short. Palpi entirely yellow.

Anterior and posterior angles of prothorax rounded, posterior ones more so ; anterior margin narrower than the posterior, anterior and postero-lateral systematic series distinct, composed of moderately coarse punctures.

Elytra not 1½ times as long as wide, suture very narrowly blackish, systematic series of coarser punctures not well developed but there are two basal punctures on each side of scutellum.

Mentum shining, with some very minute punctures on the side and a semi-circular shining excavation in the middle of anterior margin. Mesosternum minutely protuberant in the middle before intermediate coxae. Emargination of the last ventral segment very shallow and wide. All femora except the knees pubescent. Tibiae very spinulose. Tarsi yellow.

Aedeagus at its end V-shaped ; the parameres being widened at their apex to an oblique foot-like appendage, which is minutely toothed or hooked at its outer and anterior edge ; at their apices the appendages are rounded. The median lobe is not protruding but embedded in between the two parameres, shorter and much narrower, parallel-sided and rounded at the apex.

Pelthydrus similis, sp. nov.

Type : No. $\frac{3806}{H4}$. In the Zoological Survey of India (Indian Museum), Calcutta. Nerbudda Survey, sta. 56, Rewa State, Machrar Nala

tributary at Chapra, 2,625 feet; March 1927 (H. S. Pruthi); 2·6×1·3 mm.

Paratypes: Nos. $\frac{3807\text{-}3811}{H4}$. Same locality, date, altitude and collector; sta. 51, same Survey, the river opposite the camp at Kachratola, 2,625 feet; March 1927 (H. S. Pruthi); a few. Sta. 38, the river about 3 miles (east) from Koilari, Rewa State; February 1927 (H. S. Pruthi); a single specimen.

This is the 12th *Pelthydrus* discovered; it comes very near *vitalisi* d'Orchymont, being of about the same size (2·5-2·6 mm.), 8-jointed antennae, not punctate-seriate elytra, not very small eyes, carinate prosternum, in the middle of body not much widened and not of navicular shape, with also close and coarse punctation on the wing cases. The colouration of the upper surface is the same: deep blackish, with the disc of prothorax and elytra bordered more widely with clearer brown or even yellow. The palpi are uniformly reddish as also the feet with only the tibiae more or less infuscate. The anterior side of the forehead is widely and more deeply emarginate, as in *vitalisi*, with the outer angles more sharply protruding. The prothorax is moderately convex, very distinctly narrowed behind with the posterior margin distinctly narrower than the anterior (in *vitalisi* more convex and nearly of same width before and behind). The anterior angles are entirely rounded. The sculpture of the prothorax is also somewhat different: under a high power the large punctures seem preceded by a much finer one which has a tendency to coalesce in the longitudinal direction, so that the punctures seem more distinctly geminate than in *vitalisi*. The elytra are more parallel-sided, less attenuate posteriorly and less convex than in that species, without the faintest trace of a serial arrangement of some of the otherwise nearly as dense and strong punctures.

On the under side the mesosternal process is not arrow-head shaped as in *vitalisi*, but the longitudinal carina is only limited before by a half circular and obscurely raised line. Seen from the side the process is not so protuberant before as in *vitalisi*. The first ventral segment is, therefore, less distinctly carinate.

Berosus (Enoplurus) fallax, sp. nov.

Type: No. $\frac{3812}{H4}$. In the Zoological Survey of India (Indian Museum), Calcutta. Nerbudda Survey, Central Provinces, sta. 83; small pools near the river channel at Mandla; ♂, 4·9×2 mm.; November 1927 (H. S. Pruthi).

Paratypes: Nos. $\frac{3813\text{-}3819}{H4}$. Same locality, date and collector; ♂♂♀♀. Same Survey, the Taba tributary at Babai, Central Provinces, sta. 103; 17th December 1927; still water; 1 ♂ (H. S. Pruthi); the river at Hoshangabad (Central Provinces), sta. 104; December 1927, 1 ♀ (H. S. Pruthi).

Nearest to *fairmairei* but on an average somewhat smaller and more coarsely sculptured, with the elytral striae, especially at base and along suture, deeper impressed and the interspaces more densely and more coarsely punctured, the sutural angle of elytra of ♂ more produced than in the ♀, the parameres of aedeagus very long, rounded at extremity

(very acutely pointed in *fairmairei*) and the median lobe not abruptly widened at the end, which is coated with dense, very short, microscopical setae; median orifice distal (median lobe in *fairmairei* strongly arcuate but only in one direction—convexity ventral—the end abruptly widened, coated also with very short setae and with median orifice nearly distal).

Upper side of a yellow testaceous colour, very obscurely darkened by brown spot-like markings: two on the postfrons, sometimes two geminated ones towards the anterior side of prothorax, one along the suture of elytra beyond the middle and two others more exterior ones before and another behind the sutural one. These elytral markings are rather darkenings of a short portion of the 2nd to 4th, 7th to 9th and 5th to 7th striae.

Head and prothorax more densely and more regularly punctured than in *fairmairei*, otherwise very similar in general form and disposition. Each elytral puncture of interstices bears a short yellow procumbent hair. Exterior spine long and slender, a trifle more so than in *fairmairei*.

Mesosternum with a low median elevated carina. Metasternal median process triangular and advanced towards posterior coxae and deeply unifoveolate below. First ventral segment obscurely carinate at base. Fifth abdominal segment with a wide and very shallow emargination, not toothed at the bottom, inconspicuously more abrupt at the sides as in *fairmairei*. Claws of tarsi long as in that species.

♂. Anterior tarsi tetramerous, the basal joints enlarged, elytral interspaces not reticulate between punctures. Fifth ventral segment with a shallow emargination as remarked above, nearly 4 or 5 times as wide as deep.

♀. Anterior tarsi pentamerous, basal joints not enlarged, elytral interspaces very distinctly reticulate, 5th abdominal segment not emarginate at the end but widely and inconspicuously truncate at the end, the truncate portion being nearly twice as wide as the emargination of ♂.

COLEOPTERA PALPICORNIA FROM THE KHEWRA GORGE, SALT RANGE, PUNJAB.

By A. D'ORCHYMONT, *Brussels.*

Some time back I received from Dr. H. S. Pruthi some Coleoptera Palpicornia collected by him and Dr. S. L. Hora of the Zoological Survey of India during a survey of the Khewra Gorge, Salt Range, Punjab. According to Dr. Pruthi there is a small stream at the Khewra Gorge, the water of which is fresh three miles above the Khewra village, but gradually becomes saline nearer the village. It is a stream only during and just after the rainy season, and for the most part of the year it consists of only a chain of pools, more or less connected with one another, in some cases by under-ground water channels. As noted above, the salinity increases on approaching the Khewra village and near the village itself is more than twice that of the sea[1]. Of course under such uncertain conditions the salinity must be very variable according to the period of the year at which investigations are carried out.

The stations from where Palpicornia were submitted to me are the following ; the numbers of the stations follow the course of the stream upwards :

Sta. 2 ; 12.x.1930 [2]. Stream about a quarter mile beyond station 1. Salinity : 91·273. Species collected : *Ochthebius flumineus*, sp. nov., *O. explanatus*, sp. nov., *Enochrus* (*Lumetus*) *sinuatus*, sp. nov., *Berosus* (*s. str.*) *nigriceps* (F.), and *B. insolitus*, sp. nov.

Sta. 3 ; 13.x.1930. A couple of hundred yards beyond station 2 and near the first sharp turning of stream. Salinity : 42·357. Species collected : *Enochrus* (*Lumetus*) *sinuatus*, sp. nov., *Berosus nigriceps* (F.)

Sta. 4 ; 13.x.1930. A small highly saline streamlet flowing on the side of station 3. Salinity : 143·889 [3]. Species collected : *Enochrus* (*Lumetus*) *sinuatus*, sp. nov., *Berosus nigriceps* (F.), *Berosus insolitus*, sp. nov.

Sta. 5 ; 9.iv.1931. A large deep pool in the course of the stream at the turning about 50 yards beyond stations 3 and 4. Salinity : not indicated (fresh water ?). Species collected : *Laccobius gracilis* Mots., *Enochrus* (*Lumetus*) *sinuatus*, sp. nov., *Sternolophus rufipes* (F.), *Berosus* (*s. str.*) *nigriceps* (F.)

Sta. 7 ; 31.iii.1931. A large pool in the course of the stream between stations 6 and 8. Salinity : 6·366. Species collected : *Laccobius gracilis* Mots., *sinuatus* d'Orchymont, *Helochares* (*Agraphydrus*) *stagnalis*, sp. nov., *Sternolophus rufipes* (F.)

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[1] H. S. Pruthi—" An Ecological Study of the Fauna of the Khewra Gorge and some other Salt Waters in the Salt Range, Punjab " *Rec. Ind. Mus.*, XXXV, pp. 87-119, with one text-figure (1933).

[2] Some of the labels bear the date 30.x.1930.

[3] About 4½ times as much as the salinity of the Indian Ocean.

Sta. 9 ; 10.iv.1931. A series of small pools and rapids in the course of the stream, 50 yards beyond station 8. Salinity : 1·979. Species collected : *Coelostoma horni* (Régimbart).

Sta. 10 ; 2.iv.1931. A small pool in the course of the stream near the place where the water-pipe crosses the stream. Salinity : 0·608. Species collected : *Enochrus* (*Methydrus*) *tetraspilus* (Régimbart).

Of the eleven species represented in the collection, five are new to science. Some of them (*Ochthebius flumineus* and *O. explanatus*, *Enochrus sinuatus* and *Berosus insolitus*) appear as if they were at least halophilous, if not halobiont, although the third (*Enochrus sinuatus*) was also collected at station 5, where the salinity seems to have been so low, on the 9th of April 1931, as to be not worth recording. At stations 2 to 5 with these four species specimens of *Berosus nigriceps* (F.) were also collected ; this species is widely distributed throughout India. In spite of Knisch's statement in his catalogue, it is specifically distinct from the cafrarian *punctulatus* of Boheman. Most of the species studied are rather of a Palaearctic character, but *Coelostoma horni* and *Sternolophus rufipes* are certainly Indo-Malayan. The subgenus *Helochares* (*Agraphydrus*) has an extensive range of distribution, from tropical Asia over Sumatra, Java and Bali as far as Madagascar and even continental East Africa.

The table on the opposite page shows the exact localities from which the various species were collected.

Ochthebius (Hymenodes) flumineus, sp. nov.

Type : No. $\frac{3820}{H4}$. Indian Museum ; ♂ ; Station 2 ; 12.x.1930 ; 2×0·8 mm.

Paratypes : Nos. $\frac{3821\text{-}3826}{H4}$. ♂♂♀♀. Same locality and date (Station 2) ; few specimens.

This new species can be distinguished from the closely allied species (*difficilis* Mulsant, *schneideri* Kuwert, *aeneocupreus* J. Sahlberg) by its smaller prothorax as compared with the hind body, by the labrum being conspicuously notched in the middle of its anterior margin, by the elytra of the ♀ gradually and widely expanded behind the shoulders to nearly the sutural angle, the expanded margin having its greatest width just before the middle. The aedeagus differs from that of *aeneocupreus* by the extremity of the median lobe being much more smaller and less widely spatuliform.

Upper side black with a cupreous or purpuraceous hue and fine recumbent hairs. Palpi and legs testaceous brown, with the extremity of 5th joint of tarsi somewhat infuscate. Forehead shining, sparsely and finely punctate, the clypeal suture transversely deepened in the middle. Space between the inter-ocular foveae and before the posterior one also shining, sparsely and finely punctate. Labrum notched in the middle but not very deeply.

Sclerified portion of prothorax irregularly hexagonal, much more narrowed towards the base than towards the apex, lateral angulation being on the first third ; behind this angulation the sides are not serrate and nearly straight or but little curved inwards to the posterior angles, and bordered with a pellucid narrow membrane. The fore side is also

Stations.	1[1]		2		3		4		5		7		9	10	11
Date.	11.x.30.	27.iii.31.	12.x.30.	9.iv31.	13.x.30.	9.iv.31.	13.x.30.	9.iv.31.	14.x.30.	9.iv.31.	14.x.30.	31.iii.31.	10.iv.31.	2.iv.31.	3.iv.31.
Salinity.	78·529	166·830	91·273	123·961[2]	42·357[3]	51·057[4]	143·889[3]	130·82[3]	38·856[5]	?	5·174[6]	6·366	1·979[6]	0·603[6]	0·192[6]
Hydraenidae.															
1. *Ochthebius* (*Hymenodes*) *flumineus*, sp. nov.			×												
2. *Ochthebius* (*Hymenodes*) *explanatus*, sp. nov.			×												
Hydrophilidae.															
3. *Coelostoma horni* (Régimbart) .													×		
4. *Laccobius* (*s. str.*) *gracilis* Mots.										×		×			
5. *Laccobius* (*s. str.*) *simulans* d'Orchymont.												×			
6. *Helochares* (*Agraphydrus*) *stagnalis*, sp. nov.												×			
7. *Enochrus* (*Lumetus*) *sinuatus*, sp. nov.			×		×		×			×					
8. *Enochrus* (*Methydrus*) *tetraspilus* (Régimbart).														×	
9. *Sternolophus* (*s. str.*) *rufipes* (F.)										×		×			
10. *Berosus* (*s. str.*) *nigriceps* (F.)			×		×		×			×					
11. *Berosus* (*s. str.*) *insolitus*, sp. nov.			×				×								

[1] According to Dr. Pruthi's report *Ochthebius* sp., *Berosus nigriceps* and *Berosus* sp. (larvae) were present, but no specimens were submitted for identification.
[2] According to the same report *Ochthebius* sp., *Enochrus* sp., *Enoplurus* sp. and ? *Berosus* sp. (larvae) were present, but no specimens were submitted for identification.
[3] According to the same report *Ochthebius* sp. present, but not submitted for identification.
[4] According to the same report *Ochthebius* sp. and *Enochrus* sp. present, but not submitted for identification.
[5] According to the same report *Palpicornia* were captured, but not submitted for identification.
[6] According to the same report ? *Berosus* sp. present, but not submitted for identification.

bordered with such a narrow membrane, and is only faintly emarginated behind the normally convex eyes; the anterior angles do not project forwards. Immediately behind these angles the lateral border has 3-4 very small tooth-like asperities. The disc is shining and sparsely punctured but more strongly than on the head. There is a deep and narrow median furrow, on each side of this furrow are the lateral foveae, the anterior ones somewhat smaller and shorter than the posterior, and the lateral ear-like projections of the disc are very finely reticulate-granulate.

Elytra wider at the base than at the base of prothorax, widest a little beyond the middle, separately rounded at the extremity. They are provided with ten regular not striated rows of moderately impressed and not very large punctures. The interspaces of rows are wider than the punctures, and wider also than the space separating two succeeding punctures of the same row. Out of each puncture a recumbent hair arises, and as a result the pubescence of elytra appears to be arranged in regular distanced rows. The external, not serrate but entire border, seen from above is not expanded in the males, but is widely so in the females, as described above. One of the females has its elytra particularly widened.

The pygidium protrudes somewhat in both sexes, between the median emargination at the sutural angle of elytra.

Ochthebius (Hymenodes) explanatus, sp. nov.

Type: No. $\frac{3827}{H4}$ Indian Museum; ♂; Station 2; 12.x.1930; $1{\cdot}47 \times 0{\cdot}6$ mm.

Paratypes: Nos. $\frac{3828\text{-}3839}{H4}$. ♂♂♀♀; same locality and date (Station 2): numerous specimens.

The ♀ has its elytra expanded as in females of *flumineus*, but the latter species is larger, much more shining, without reticulation upon the elevated parts of the disc of the head and prothorax.

Also the aedeagus is different: in *explanatus* the terminal mobile piece is only gradually and not greatly, more or less triangularly widened at the extermity, while in *flumineus* it is abruptly widened at the end into a more or less rounded spatuliform flattened plate.

O. explanatus by its long legs and widened elytra, especially in the ♀, recalls somewhat the subgenus *Doryochthebius*, but the anterior angles of the prothorax do not protrude forwards like finger-like processes and the anterior border near those angles is not emarginate behind the eyes (deeply excised in *Doryochthebius*). *O. andraei* Breit (Mesopotamia: Hit) and *reflexus* Sahlberg (Transcaspia: Mulla Kara) differ by their size (2 mm.) and in other particulars, *vide* their descriptions.

Of a black colour with greenish metallic hue, the legs and palpi, with the exception of their last joint which is clear yellowish, of a brownish colour. Head and prothorax even on the elevated parts are microscopically reticulated. The labrum is somewhat deeper notched in the middle as in *flumineus*. The clypeal suture is transversely depened in the middle and the posterior fovea of head is much smaller than the two interocular ones.

Prothorax narrower behind than in front, but with no conspicuous angulation on the sides. The sclerified disc is widest in the anterior third, wider here than the head with the eyes, with the anterior angles completely rounded and provided with some very small tooth-like asperities, gradually attenuated in the two last thirds with the lateral borders nearly straight or only feebly arcuated inwards, not serrate. A delicate and narrow membrane is to be observed along the anterior and posterior borders and along the hind lateral attenuation. Median longitudinal groove not very narrow, with the two foveae on each side of this groove—the anterior smaller than the posterior—rather shallow and still more reticulated. The same may be said of the lateral ear-like expansions.

Elytra much wider at the base than the base of the prothorax, having their greatest width beyond the middle. At the extremity they are separately rounded, leaving a small common emargination on the sutural angles. No serration at the sides. They are covered with ten not so conspicuously separated rows of punctures as in *flumineus*, the punctures are also nearer to one another, more shallow and not so well defined. Interspaces are also less wide. The superficial pubescence is less conspicuous than in the allied species. The females with their more depressed, shield-like elytra, and widened more or less brownish more expanded lateral margins look very peculiar.

Seen from above the pygidium is somewhat protruding between the sutural angles of the elytra.

Coelostoma horni (Régimbart).

♂♀; Station 9; 10.iv.1931. The aedeagus of ♂ has been compared. Described from Ceylon but recorded also from continental India and even, but very sparingly, from tropical Africa.

Laccobius (s. str.) gracilis Motschulsky.

(Syn. *L. orientalis* Knisch).

A few specimens, ♂♂ and ♀♀, from Station 5 (9.iv.1931) and Station 7 (31.iii.1931). A typical Palaearctic species.

Laccobius (s. str.) simulans d'Orchymont.

A single ♀ from Station 7 (31.iii.1931). Described from Yunnan and North India.

Helochares (Agraphydrus) stagnalis, sp. nov.

Type: No. $\frac{3840}{H4}$. Indian Museum; Station 7; 31.iii.1931; 2·4× 1·2 mm.

Paratypes: Nos. $\frac{3841\text{-}3842}{H4}$. Same locality and date (Station 7); both sexes.

This *Agraphydrus* has distinctly 9-jointed antennae. It differs from all the described species, except *kempi* d'Orchymont, by its more parallel-sided, narrower and more elongate shape; from *coomani* d'Orchymont by the preocular spots smaller, the almost entirely obscure

prothorax, narrowly bordered at the sides by a band of a testaceous colour, by the more slender median lobe of the aedeagus, by the more broadly truncate extremity of parameres (attenuate and more narrowed at the end in *coomani*); from *kempi* by the larger, less elongate shape, the less dense punctation of the head, the more rounded posterior angles of prothorax, the less strong, less dense, nearly obsolete punctation of wing cases; from *orientalis* d'Orchymont by the not reticulate forehead which is distinctly but finely punctured, of the same type as on the postfrons, by the prothorax more obscure, less broadly margined by testaceous colour at the sides, a trifle more strongly punctured, by the median lobe of aedeagus which is very slender, elongated, cylindrical (wide, flattened and nearly truncate at the end in *orientalis*); from *pauculus* Knisch by the less obscure elytra, the finer and more sparse punctation of head, prothorax and especially of the wing cases; from *punctatellus* Régimbart by the different colouration (eyespots not so large, prothorax more obscure, etc.), and by the parameres of aedeagus more broadly truncate at the end, their outer margin nearly straight, not rounded; finally from *pygmaeus* Knisch by the much finer punctation of the upper side, especially of the wing cases, and by the much less obscure colouration.

Head, including labrum, and prothorax shining black, with small preocular testaceous spots and the prothorax at the lateral sides not widely bordered with the same colour. Wing cases more brown, narrowly bordered with testaceous at the sides and the suture very narrowly black. Entire palpi and tarsi yellow. Punctation very fine and of the same form on fore- and hind head, nearly of the same shape and density on the prothorax, very much more obsolete on the wing cases. On these the two coarse punctures on each side of the scutellum are easily observed; the inner series of coarser punctures are very sparsely furnished, the inner one not so widely separated from its basal puncture as the second; the third series has also only a few widely separated punctures; the outer one (4th) has more punctures and reaches nearly the base of wing cases.

Mentum with an anterior rounded emargination, with some coarse punctures and oblique ridges at the sides. Emargination of 5th ventral segment minute and not very distinct.

Enochrus (Lumetus) sinuatus, sp. nov.

Type: No. $\frac{3843}{H4}$. Indian Museum. Station 5; 9.iv.1931; ♂; 4·6×2·2 mm.

Paratypes: Nos. $\frac{3814\text{-}3854}{H4}$. Same locality and date: a few ♂♀; Station 2: 12.x.1930: ♂♂♀; Stations 3 and 4: 13.x.1930: ♂♂, ♀♀.

A halophilous *Enochrus* representing in the Salt Range our common also halophilous *bicolor* Fabricius. It is at once distinguished from that species by the very obsolete sculpture of the upper surface, by the (in both sexes) deep black labrum and by the bordered lateral margin of elytra which is not regularly rounded in its second half, but distinctly curved in and then again curved out on its third fourth, more so in several females than in males. The portion of elytra just near the lateral margin is distinctly turned up. Both sexes are of the same colour;

yellow testaceous with the exception of the black labrum, a variable transverse anterior blackish spot on the forehead, joined to the equally obscured Y-suture by a longitudinal obscure band, four black punctures on the disc of prothorax and an obscure humeral spot. The elytra are ordinarily more or less tinged with clear brown. Palpi, including the last and pseudo-basal joints, entirely yellow; antennae of the same colour, the club (joints 7-9) more obscure; legs testaceous, only the base of femora and the claws obscured.

From *fragilis* Sharp and *fretus* d'Orchymont it is distinguished at a glance by the much larger claws, the different and more testaceous colouration, the reduced sculpture of the upper surface, reduction of femoral hydrofugal pubescence, the aedeagus otherwise built, etc.

Upper side oily shining, head not very densely and finely punctulate, with some larger punctures behind labrum and along the transversal suture. Palpi not very long, nevertheless longer than the head and with the last joint much shorter than the foregoing. Eyes of moderate size, not very convex.

Prothorax on the disc still more finely punctulate than the head, with antero-external and postero-lateral systematic punctures of same form as on the head.

Scutellum and front side of elytra finely bordered with black. Elytra highly polished, with very obsolete punctation, so that the two inner irregular rows of larger systematic punctures, though not much larger than on the prothorax, are more conspicuous; along the lateral margin there are also such punctures but irregularly placed. On the disc one can count 9 series and the beginning of a juxta-scutellar supplementary short series of black, not closely placed punctures, which are only seen by transparence.

Under side black, mentum shining, in the ground with some punctures of medium strength. Prosternum not carinate, not toothed on the middle of its anterior margin. Mesothorax with a roof-like carinate protuberance anteriorly very minutely toothed. Fifth (last) ventral segment without ciliated emargination. Basal half of anterior and median femora infuscate and pubescent; only basal third of posterior femora pubescent and more or less infuscate. Claws very large; inner and outer claws of ♂ identical, all tarsi hooked and minutely lobbed at base. Claws of ♀ not hooked, somewhat longer than in ♂, obscurely toothed at base. Onychium in both sexes much shorter than the claws.

Median lobe of aedeagus parallel-sided, band-like as in *fragilis*, but less short with more protruding terminal dorsal strut. Parameres longer than the median lobe.

Enochrus (Methydrus) tetraspilus (Régimbart).

One specimen; Station 10; 2.iv.1931; salinity only 0·608. Not halophilous.

Sternolophus (s. str.) rufipes (Fabricius).

One specimen : Station 5 : 9.iv.1931 ; another : Station 7 : 31.iii.1931. Not halophilous.

Berosus (s. str.) nigriceps (Fabricius, 1801).

Berosus aeneiceps Motschulsky, 1861 (Ceylon).
? *Paraberosus melanocephalus* Kuwert, 1890 (Arabia).
? *Paraberosus nigriceps* Kuwert, 1890 (Persia, Mesopotamia).
Berosus immaculicollis Fairmaire, 1892 (Obock).

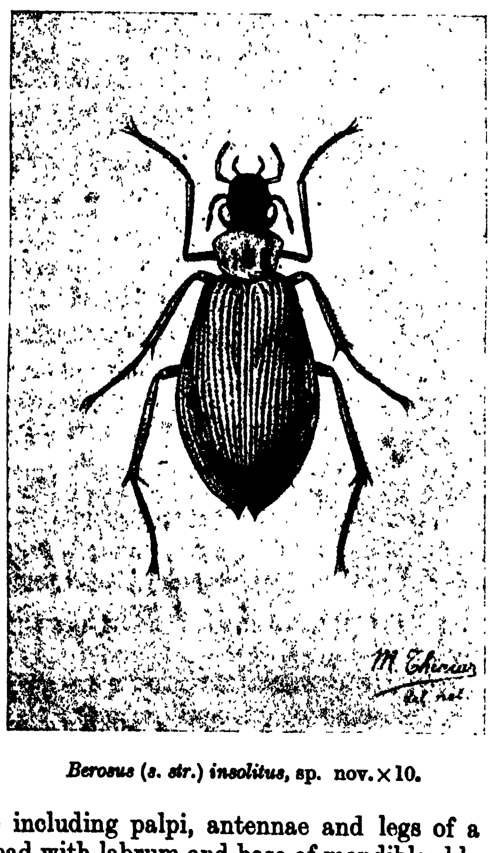
Stations: 2 (12.x.1930), 3 (13.x.1930), 4 (13.x.1930) and 5 (14.x.1930); several ♂♂ and ♀♀. Species described from "India orientalis". Not halophilous.

Berosus (s. str.) insolitus, sp. nov.

Type: No. $\frac{3855}{H4}$. Indian Museum. Station 4; 13.x.1930; ♂; 4×1·9 mm.

Paratypes: Nos. $\frac{3856\text{-}3863}{H4}$. Same locality and date; Station 2; 12.x.1930; a few ♂♂ and ♀♀.

This species stands unique among the European and Asiatic species of *Berosus* and can readily be distinguished by the elytra which in both sexes are unispinose at the sutural angle. In both sexes the elytra are also much widened beyond the middle.



Berosus (s. str.) insolitus, sp. nov. ×10.

Upper side including palpi, antennae and legs of a general yellow colour, only head with labrum and base of mandibles black and metallic, of a green and purple hue; the apex of mandibles more or less reddish,

the prothorax and elytra here and there only very faintly infuscated, the punctures of elytral series each surrounded by infuscation.

Head with Y-suture very conspicuous, placed in a depression, the disc (fore- and hind head) covered with not very closely placed and rather coarse and deep punctures. Eyes globose and prominent. Vertex (after the postfronto-vertical suture) obscure, shining and without punctation. Last joint of maxillary palpi very faintly obscured round the apex.

Prothorax distinctly wider than long, fringed with long hairs on the lateral sides which in the middle are gently curved in, distinctly narrowed behind; the anterior angles much rounded, the posterior also but less and more obtuse; anterior and posterior margin curved out, the former towards the head, the latter towards the scutellum; disc with rather fine punctures in the middle, coarser and denser at the sides where they are not all of one size.

Scutellum more or less obscure. Elytra, in both sexes, very conspicuously inflated at the sides, the inflation having its maximum in the middle; they are divaricate at the apex and each sutural angle is prolonged into a triangular and acute expansion or tooth. The ten normal and the eleventh shortened (juxta-scutellar) series are composed of punctures of moderate strength, nearly three times smaller as the intervals are wide. These interspaces are flat, more shining in the ♂, obscurely alutaceous in the ♀. The rather long juxta-scutellar series of punctures is often individually irregular.

Claws in both sexes long. In the ♂ the second joint of anterior tarsi is much inflated.

Mesosternum with a very obscure raised longitudinal line in the middle. Metasternum in the middle before the hind coxae with a small and ovate excavation. First ventral segment with a longitudinal median and basal carina. Fifth segment in both sexes without emargination.

NOTES ON FISHES IN THE INDIAN MUSEUM.

XXIX.—On a Collection of Fish from Nepal.

By SUNDER LAL HORA, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta.*

Nepal is generally regarded as a closed country to travellers and it is no wonder, therefore, that very little is known about its fauna. The lack of knowledge about the ichthyology of the Nepal Himalayas is a great handicap in any discussion concerning the geographical distribution of fishes that have been recorded from the eastern and the western parts of this great mountain chain. In 1907, Regan[1] reported on a small collection of fish obtained from Nepal and recorded the following species :—

1. *Oreinus richardsonii* Gray	Soondrijal hills above Katmandu.
2. *Diptychus annandalei* Regan . . .	Pharping (Katmandu Valley).
3. *Saccorbranchus fossilis* (Bloch) . . .	Katmandu.
4. *Euchiloglanis blythii* (Day)	Pharping.
5. *Ophiocephalus punctatus* Bloch . . .	Pharping.

In 1923, I[2] pointed out that the Nepal specimens referred by Regan to *Euchiloglanis blythii* (Day) did not belong to that species and had to be referred to a new species which I designated as *Glyptosternum hodgarti*. This species is fairly common in the rivers below Darjiling and in the hill ranges of Assam. In 1931, Mukerji[3] discussed the generic position of *Diptychus annandalei* and came to a tentative conclusion that it should be referred to the genus *Schizothorax* or, if the absence of scales turns out to be a constant feature of the adults, to a new genus intermediate between *Schizothorax* and *Diptychus*.

From the beginning of 1935 Colonel F. M. Bailey, Resident at the British Legation, Nepal, has at my request sent four lots of fish from the Nepal territory and these form the subject matter of this note. Though no new species of fish is represented in this valuable collection, I have been enabled to extend the range of the remarkable genus *Semiplotus* Bleeker which had hitherto been recorded from Burma, the Assam hills and the Darjiling Himalayas and to record variation in colour in the case of *Barilius vagra* Ham. The occurrence of *Labeo dyocheilus* (McClelland) is also of some interest as the species had hitherto been known from the Assam hills on the one hand and Hardwar and Simla on the other.

In all 158 specimens belonging to 22 species were sent by Col. Bailey, but those from Devighat were not in a good condition to be preserved. The remaining specimens have been incorporated in the collection of

[1] Regan, *Rec. Ind. Mus.*, I, p. 157 (1907).
[2] Hora, *Rec. Ind. Mus.*, XXV, p. 38 (1923).
[3] Mukerji, *Rec. Ind. Mus.*, XXXIII, p. 63 (1931).

the Zoological Survey of India (Indian Museum). I take this opportunity to offer my sincerest thanks to Col. F. M. Bailey for his kindness in collecting fishes from this interesting area and presenting the same to the Zoological Survey.

The entire material is listed below according to the localities:

Devighat (Lat. 27° 50′, Long. 85° 5′), 2 days march west of Katmandu (April, 1935).
1. *Barilius vagra* Ham. . . . . . 14 specimens.
2. *Crossochilus latius* (Ham.) . . . . 1 specimen.
3. *Barbus* sp. (juvenile) . . . . . 3 specimens.

Hulchok (on Gandak River near Lat. 28° 15′, Long. 84° 50′), 2,500 ft. (10.viii.1935).
1. *Oreinus richardsonii* Gray . . . . 8 specimens.

Mangning (about Lat. 28° 10′, Long. 85° 10′), 5,000 ft. (13.viii.1935).
1. *Oreinus richardsonii* Gray . . . . 6 specimens.

Nagarkot, (Lat. 27° 40′, Long. 85° 30′) 5,500 ft. (20.ix.1935).
1. *Oreinus richardsonii* Gray . . . . 14 specimens.
2. *Nemachilus rupicola* var. *inglisi* Hora . . 5 specimens.

Sundarwal (Central Nepal), 5,500 ft. (20.ix.1935).
1. *Oreinus* sp. (juvenile) . . . . 6 specimens.

Katmandu, 4,500 ft. (29.ix.1935).
1. *Ophicephalus punctatus* Bloch . . . 37 specimens.

Tribeni (Lat. 27° 26′, Long. 83° 56′), Nepal Terai (5.xii.1935).
1. *Chela baicala* (Ham.) . . . . . 1 specimen.
2. *Laubuca laubuca* (Ham.) . . . . . 1 specimen.
3. *Barilius bendelisis* (Ham.) . . . . . 5 specimens.
4. *Barilius tileo* Ham. . . . . . . 9 specimens.
5. *Barilius shacra* Ham. . . . . . 3 specimens.
6. *Barilius vagra* Ham. . . . . . . 5 specimens.
7. *Barilius* (*Opsarius*) *bola* Ham. . . . . 1 specimen.
8. *Aspidoparia jaya* (Ham.) . . . . . 4 specimens.
9. *Aspidoparia morar* (Ham.) . . . . 6 specimens.
10. *Labeo dero* (Ham.) . . . . . . 1 specimen.
11. *Crossochilus latius* (Ham.) . . . . . 7 specimens.
12. *Barbus putitora* (Ham.) . . . . . 1 specimen.
13. *Nemachilus scaturigina* (McClell.) . . . 1 specimen.
14. *Ailia coila* (Ham.) . . . . . . 10 specimens.
15. *Clupisoma garua* (Ham.) . . . . . 2 specimens.
16. *Xenentodon cancila* (Ham.) . . . . 4 specimens.

Nepal Terai, near Tribeni (February, 1936).
1. *Labeo dero* (Ham.) . . . . . . 1 specimen.
2. *Labeo dyocheilus* (McClell.) . . . . 1 specimen.
3. *Semiplotus semiplotus* (McClell.) . . . 1 specimen.

Barilius vagra Hamilton.

In 1872, Day[1] described *Barilius modestus* from the Indus in Sind and the Ravi River at Lahore. So far as can be judged from its description, he distinguished it from the common *B. vagra* Ham. by the absence of the vertical colour bars. I have examined a typical specimen of the species in the collection of the Indian Museum and have compared it with specimens of *B. vagra*. There are no morphological features on which the two species can be recognised from each other. In Col. Bailey's collection there are 5 specimens from Tribeni which I have referred to *B. vagra*; they lack any colour markings on the body, except that the dorsal surface is grayish and strongly marked off from the silvery sides. The examination of these specimens has convinced me that Day's *B. modestus* is only a colour variant of *B. vagra* and not a distinct species.

[1] Day, *Journ. As. Soc. Bengal*, p. 4 (1872); *Fish. India*, p. 589, pl. cli, fig. 3 (1878).

To facilitate reference in future I give below a table of measurements of the Nepalese specimens :

Measurements in millimetres.

Total length	59·0	67·0	69·0	84·0	92·5
Length of caudal	10·0	13·5	13·5	18·0	21·3
Length of head	11·0	13·0	13·0	14·3	15·5
Height of head	7·0	8·5	8·8	10·0	11·3
Width of head	5·0	6·0	6·0	7·0	8·0
Diameter of eye	3·0	3·5	3·9	4·0	4·5
Interorbital width	3·3	3·3	4·0	4·3	5·0
Length of snout	3·0	3·8	3·8	3·8	4·0
Height of body	10·0	12·0	11·3	14·0	15·8
Width of body	5·0	6·0	6·0	6·3	7·0
Length of caudal peduncle	7·0	8·0	8·0	8·0	8·5
Least height of caudal peduncle	5·0	6·0	5·5	7·0	7·5
Longest ray of dorsal	9·0	10·0	10·0	11·5	14·0
Longest ray of anal	8·0	8·5	8·5	8·5	12·0
Length of pectoral	9·5	10·0	10·0	13·0	13·4

Labeo dyocheilus (McClelland).

Recently I[1] pointed out the distinguishing features of *Labeo dyocheilus* and showed the characters in which it differs from *Labeo dero* (Ham.). At the same time it was indicated that the collection of the Indian Museum contained only 4 specimens of this species—1 from Simla, 1 from Hardwar and 2 from Assam. The addition of one more specimen to the collection from an intermediate region is, therefore, of great value.

Semiplotus semiplotus (McClelland).

Semiplotus semiplotus was described by McClelland[2] from Assam and placed in the genus *Cyprinus* with only one other Indian species *Catla catla* (Ham.). Bleeker[3] proposed a new genus *Semiplotus* for it and this he defined as follows, presumably without examining any specimen of the species :

" Rostrum integrum lateribus non lobatum. Maxilla superior non protractilis. Ossa nasalia et suborbitalia cum maxilla superiore coalita. Labia continua nec crenata nec fimbriata. Cirri nulli. Pinna dorsalis elongata spina edentula armata, supra analem desinens. Squamae magnae."

Günther[4] recognised Bleeker's genus without any emendation, but he had only one bad skin for examination. In 1870, Day[5] described another species—*S. modestus*—in this genus from the hill-ranges of Akyab and remarked :

" This species appears intermediate between the genera *Semiplotus* and *Cyprinion* ; for it nearly agrees with the former in the slight motion

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[1] Hora, *Rec. Ind. Mus.*, XXXVIII, p. 320 (1936).
[2] McClelland, *As. Res.* (Ind. Cyprinidae), XIX, pp. 274, 346, pl. xxxvii, fig. 2 (1839).
[3] Bleeker, *Atl. Ichth.*, III, p. 25 (1863).
[4] Günther, *Cat. Fish. Brit. Mus.*, VII, p. 204 (1868).
[5] Day, *Proc. Zool. Soc. London*, p. 101 (1870).

of the upper jaw, absence of barbels, etc., whilst it likewise resembles the latter in having a serrated dorsal spine, although it has no bony edge to the lips or barbels."

Chaudhuri[1] described a third species of *Semiplotus*—*S. cirrhosus*—from very young specimens and distinguished it from the other two species by the possession of two small maxillary barbels and by the absence of a knob at the symphysis of the lower jaw. Col. Bailey's specimen from Nepal was identified as *Semiplotus semiplotus* but was found to possess two small maxillary barbels in the groove at the corner of the mouth. This led me to examine other specimens of the species in the collection of the Indian Museum and in every case the maxillary barbels were found to be present. In young individuals they are relatively much longer and project outside the groove whereas in half-grown and adult specimens they are more or less concealed, but it is not very difficult to make them out. Similar barbels are also present in Day's *S. modestus*. It is clear, therefore, that the presence of small, maxillary barbels is a constant feature of the genus. I am of opinion that Chaudhuri's unique specimen of *S. cirrhosus* is only a young of *S. semiplotus*. Day's species with the serrated dorsal spine is, however, quite distinct.

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[1] Chaudhuri, *Rec. Ind. Mus.*, XVI, p. 280 (1919).

ON THE HABITAT AND HABITS OF *TROCHUS NILOTICUS* LINN. IN THE ANDAMAN SEAS.

By H. SRINIVASA RAO, *M.A., D.Sc., Assistant Superintendent, Zoological Survey of India, Calcutta.*

(Plate I.)

Trochus niloticus Linn., one of the largest species among the Trochidae, has a fairly wide distribution in the Indo-Pacific seas. Its range extends from Ceylon, Mergui and the Andamans and Nicobars to Samoa in a west to east direction, and from the coasts of Queensland and Western Australia through New Caledonia, Philippine and Fiji islands to Lu Chu islands in Japan in a south to north direction.[1] It probably also occurs in the Laccadive islands in the Arabian sea but the shells found there have not been identified as *T. niloticus*.[2]

Before proceeding to describe the habits of *T. niloticus* it is important to consider whether amongst the large populations of *Trochus* in the Andaman waters there are not forms, varieties, and species resembling *Trochus niloticus* in form, shape, colouration, and sculpture of the shell. On the same beds with *T. niloticus* occur commonly *T. pyramis* Born (=*T. obeliscus* Gmelin) and *T. maculatus* Linn. which are easily distinguished from *T. niloticus* by the general outline, colour and sculpture of the shell. There are, however, certain forms of shells amongst *T. niloticus* differing slightly in their outline, convexity of the base and whorls of the shell, thickness, disposition of the last whorl in relation to the penultimate and other whorls, colour, pattern, and sculpture. In the very large series of full-grown *T. niloticus* shells from various localities in the Andamans and Nicobars which I have been able to examine, there were two common types of shell (pl. I, figs. 11 and 12) (1) the broad, short-spired shell with the outlines of the last whorl curved and its periphery thickened, and with convex base, and (2) the regularly conical, long-spired shell with the outlines of the whorls more or less straight and its base flat. A third and rather uncommon type (pl. I, fig. 13) resembling the second in general facies but with a distinct broad, somewhat convex ridge along the periphery of the base of the last whorl seems also to occur, but only one example of this type was found in several thousands of shells examined. Also among young shells with a diameter upto 5 centimetres the first two types of shell occur, but with a number of intermediate forms which grade imperceptibly one into the other ; and in very young shells below 3 cms. in diameter the outlines of the whorls are masked by the peripheral hollow spinous processes on the suture. The regularly conical straight-sided type seems, however, to prevail amongst the very young shells. That the differentiation in shell-outlines was not a manifestation of sex differences was ascertained by examining the gonads of a large number of adult shells of the two types. The proportions of the two types of

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[1] Hedley (1917).
[2] Ramaswami Ayyangar (1922).

shells in large samples of collections from various localities differed widely, sometimes one type predominating over the other in numbers. von Martens (1867) was of the opinion that types 1 and 2 were distinct species, namely, *T. niloticus* Linn. and *T. maximus* Koch, and that the Indian Ocean was the common home of both the species. While the latter statement inclined Pilsbry (1889) to agree with von Martens, the very slight differences in shell-form or sculpture led him to express the opinion that *T. maximus* was an arrested and primitive form of *T. niloticus* resembling an immature specimen of the latter in its " conic form, flat lirate base and sculptured spire ", but retaining these characters in the adult stage. The differences in the environment,[1] and the changes in shell-form as a result of growth would seem to account for the occurrence of the various types of shell. Moorhouse (1933) found that in the Low Isles on the Queensland coast, retarded growth in shells of *T. niloticus* was characterised by " an extremely thick shell which is correspondingly heavier than a shell of the same diameter taken from an area of normal growth, as, for instance, from the outer surf-beaten zone of the reef ", and by " a curved base, for all shell found on the outer edge of the reef are flat-based ". In the course of my observations on growth of *T. niloticus* in the Andamans over a period of about three years, I had the opportunity to observe the changes in the form of the shell of a certain number of marked shells. These changes were usually associated with the exaggeration of the curvature of the sides of the last two or three whorls and of the base of the shell brought about, presumably, by the increased deposition of shell-substance in the region of the growing parts of the last whorl. In shells above 10 cms. in diameter these changes are more marked than in those of smaller dimensions.[2] It would appear that changes in shell-form may partly represent changes due to senescence (*vide infra*, p. 69). The proportion of the height of the shell to the maximum diameter seems also to undergo a change with the growth of the shell. In random samples of shells above 7 cms. in diameter collected from the same locality, it was observed that the difference between the height and the maximum diameter showed a tendency to increase with the size of the shell. Russell (1909) showed for *Patella vulgata* that changes in the ratios of dimensions of the shell during growth were merely " the expression of the laws of growth, and not due to natural selection ". It, therefore, seems probable that in the Andaman waters, at any rate, the various forms of *Trochus niloticus* represent either plastic phases of this species or changes in shape and outline of the shell due to differences in the rate of growth at various ages.

Although *Trochus niloticus* has been commercially exploited for over 35 years, very little is known of its habitat and habits. It lives amidst coral reefs and under rocky ledges covered with growths of green and brown algae from between tide-marks to depths upto 12 fathoms.[3] In

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[1] The Japanese divers who are licensed to fish *Trochus* in the Andaman seas have informed me that flat-based shells are more common in the Nicobar Islands than in the Andaman Islands.

[2] Moorhouse (1932) observed that in Low Isles only shells above 8 cms. in diameter had their last whorl expanded.

[3] See Watson (1886) where *T. niloticus* is reported to have been dredged in 12 fathoms off Levuka, Fiji.

the Andaman sea it is most abundant on the reefs in the inshore waters, not more than half to one mile from the rocky or sandy shore of most of the islands comprising the Andaman and Nicobar groups. The depth of the sea-floor in the reef area 'round the islands is usually between 1 to 5 fathoms, but rarely exceeds 7 fathoms. The Japanese Fishery Companies of Singapore which have been licensed to fish *Trochus* shells in the Andamans and Nicobars since 1929 employ Japanese naked divers for the purpose who are brought over to the Andamans every year in their own motor boats. The divers, with their simple but efficient hand-made water-goggles well-adjusted to their nose-bridge and eyes by elastic rubber-tubing secured to the outer ends of the goggles, swim at the surface looking down on the sea-floor, and as soon as a shell or group of shells has been sighted, dive down and bring them up.[1] Where the bottom is covered with large masses of Madreporarian coral with overhanging ledges which cast deep shadows and render the finding of shells from the surface of the sea rather difficult, the divers swim near the bottom passing in and out amongst the meandering narrow corridors and lanes at the bottom, examining the crevices and the under-surface of ledges for specimens of *Trochus*.

At the commencement of the *Trochus*-fishery in October 1929 when the beds were virgin ground, it was comparatively easy to pick up shells in very shallow water. The results of the Fishery at the end of 3 months showed that approximately 500 tons of shells had been gathered from what, presumably, were overstocked shell-beds. After 3 seasons of fishing, the shell-populations in the shallower regions between 3 to 5 fathoms were so greatly diminished in numbers that the Japanese had to extend their operations to the fishing grounds at depths of 7 fathoms. It appears that naked diving would be impossible at depths exceeding 7 fathoms, and the Japanese were soon driven to the necessity of applying for licenses for the use of diving apparatus. Actually, however, no diving apparatus was employed, presumably because of the difficulty of securing the services of special divers at Singapore for the purpose. The Japanese assert that there is still an abundant shell-population in depths beyond 7 fathoms, from which apparently the shallower regions are replenished from time to time. However, continued fishing for *Trochus* since 1929 has reduced quantities of shell fished from 500 tons to less than 40 tons in a fishing season, although the period of fishing has been doubled. There is no doubt that the shell-population has suffered considerable depletion, as may be seen from the fact that the rate of collection per diver per hour has fallen from over 20 in 1933 to 2—3 in 1935.

Moorhouse's (1932, p. 147) observation that despite a tendency for zoning of the animals in the Low Isles there was a frequent mixing of forms of various sizes does not appear to be quite in accord with mine in the vicinity of Port Blair. The young forms below 5 cms. in diameter appear to be rather scarce in depths between 2 and 7 fathoms[2] as the

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[1] For a more detailed account of the Japanese Fishing methods, boats, equipment etc., see Setna (1932).

[2] It is quite possible that the young forms occur in greater abundance at depths beyond 7 fathoms and creep gradually into shallower waters, but no evidence of such occurrence in the Andamans has been obtained.

Japanese divers in the Andamans testify, but amongst the coral shingle and under coral slabs between spring tides they are usually found at all times of the year. The type of locality in which they commonly occur is shown in fig. 1, pl. I, of the present note and in fig. 1, pl. xiv (Rao, 1936). The older forms above 5 cms. generally occur below the low-water mark of spring and neap tides.

Moorhouse (1932) also observed that *T. niloticus* was gregarious in the Low Isles of the Great Barrier Reef, as many as 15 individuals having been taken from one slab or boulder of coral on several occasions. My observations on the reefs round the Andaman and Nicobar groups of islands with the help of a water-glass, while the Japanese divers were working in those areas, showed that the individuals of the shell population on the reefs were greatly scattered, and that in consequence the divers were unable to obtain more than 2 or 3, or at the most, 5 shells at a time from a chosen spot on the reef. This may have been due to the fact that the shell-beds were, at the time of my investigation, more or less depleted of their normal stock of shells by heavy and continuous fishing. On one occasion, however, in October 1932, looking for shells in a small bay south of the South Corbyn's Cove, Port Blair, 36 specimens ranging from 5·0 cms. to 12·5 cms. in diameter were picked up either singly or in twos and threes in an area 10 yards square. Some of them were attached to the under surface of rocks, others to coral shingle, while a few were crawling on coarse coral sand in crevices under stones. A few were found on wet ground some distance below the high-water mark. The lowest tide on this day was 0·2 feet at 4-42 P.M. and the highest 6·5 feet at 10-38 A.M. (I. S. T.). The congregation of such a large number of individuals in a small area between tide-marks is no doubt exceptional, and may have resulted from the action of strong currents or some adverse weather conditions. But in comparison with other species of Gastropods such as *Nerita polita*, *N. albicella*, *N. chameleo*, *Acmaea saccharina* var *stellaris*, and *Littorina scabra* which are found in large numbers in the Andaman and Nicobar Islands on rocks between tide-marks, *Trochus niloticus* cannot be said to be really gregarious. On several occasions when marked shells were on purpose massed together round boulders under which there were adequate shelter and abundant food in the form of growths of algae, the individuals were found to have scattered within a fortnight to considerable distances from their original shelter. The tendency to wander about seems to be a feature of this species which, therefore, does not admit of its being classed among the strictly gregarious species of Gastropods.

Trochus niloticus does not seem to thrive under artificial conditions of the laboratory. Attempts to keep the animals alive in glass aquaria in which sea water was constantly kept circulated after renewal everyday proved a complete failure.[1] The longest period for which a specimen was kept alive in the aquarium was 5 days, during 3 out of which the animal was in a semi-comatose condition; but usually individuals did not survive the conditions in laboratory aquaria after 48 hours,

[1] Small reservoirs on a higher level than the aquaria were constantly filled with fresh sea-water which was led through rubber tubing into the aquaria. There were no facilities at Port Blair for a higher grade of aeration than mere renewal of sea-water,

some dying even within 24 hours. The very high degree of aeration which is maintained on the reefs is extremely difficult to imitate under the artificial conditions of the laboratory.[1] During the first three or four hours of immersion in aquaria *T. niloticus* crawls about on the small stones and shingle placed at the bottom, but in a partially expanded state in which the head and tentacles of the animal are barely visible (pl. I, fig. 2). The mouth is, however, closely applied to the surface of the stone on which it crawls in the act of browsing on the algae and the vegetable and mineral debris which constitute its food. After this period, the feeding activities of the animal cease altogether, but the foot and the columellar muscles continue to expand and contract giving the shell a partial rotary motion with the columellar muscles as the fulcrum. The epipodial lobe which in conjunction with the mantle forms the siphon for the intake of the respiratory current is observed to be mobile. After 6-8 hours in the aquarium, the animal is overcome by a state of torpor which is maintained unless disturbed. The renewed activity following any disturbance is, however, for a very short period, and the animal falls into a comatose condition again. During the first few hours of activity the animal feeds and defaecates constantly, leaving pellets of faecal matter ½ to 1 inch long in its trail. Later, it stops feeding but continues to throw out faecal pellets a little longer. Finally it withdraws itself into the shell, but with the movements of the epipodial siphon continued until the animal is actually in a comatose state. The animals seem to survive suspension in the sea for several hours or days even though they are crowded in a net bag and deprived of food.[2] They are also able to survive dessication for a little over 48 hours. On several occasions it was found convenient to transport live animals from distant beds to Port Blair by carrying them in a dry state. When exposed to the sun and wind on the open deck of the Japanese fishing boats, the live animals do not withdraw themselves into the shell and remain inactive, but protrude the whole or part of the foot gradually and withdraw it with such suddenness and force as to eject jets of sea-water from within the shell to a distance of 3 to 5 feet. This movement of the animal goes on at short intervals until the water contained in the whorls of the shell and in the tissues is dried up when the animal becomes inactive and finally dies. Some of the animals which had ceased their movements two days after their removal from the reefs were revived on immersion in the sea, and observed to grow.

It is difficult to observe the details of movements of the animals in their natural haunts between tide-marks. The quick succession of waves which dash against the coral boulders renders continuous observation impossible. At depths of about one or two fathoms the animals can be observed with the help of a water-glass[3] from a small boat

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[1] Stephenson (p. 491, 1923-25), Moorhouse (p. 147, 1932), and Weymouth (p. 9, 1923) have observed that in the case of *Haliotis tuberculata*, *Trochus niloticus*, and *Tivela stultorum* respectively ordinary laboratory conditions in aquaria are unsuitable for keeping them alive in captivity.

[2] Some animals have been observed to browse on the algae growing on the shells of other animals confined in the bag.

[3] A pyramidal trumpet-shaped wooden structure with plate-glass fixed to the broader side acting as the window.

anchored at the place of observation, but the details of their movements except when they are crawling on the vertical sides of a coral mass are obscured. Sometimes an individual may be seen crawling on a rock projecting above the surface of the water and bathed by the spray from the waves.

Although *T. niloticus* is extremely slow in its movements, it moves about a great deal in search of food and shelter. In exposed positions between tide-marks it is rarely found, but is common in holes and crevices amidst or under rocks and coral masses where algae grow in abundance. In the course of observations on growth of marked individuals (Rao, 1936) considerable difficulty was experienced in recovering them every month from the reefs, as with every ebb and flow of the tides they seemed to crawl slowly backwards and forwards. The younger individuals below 5 cms. in diameter are far more active, and move about a great deal more than the older ones above this size. Except in places protected against strong currents and waves by natural barriers provided by large masses of coral rock or by artificial piers, the recovery of the smaller animals was extremely difficult, and instances of marked shells recovered after an interval of 3 or 4 months were not uncommon. These observations show that *T. niloticus* wanders about a great deal, assisted by tides in search of food and shelter. It seems, however, improbable that it travels long stretches of the sea-bottom, particularly those between two distant islands, devoid of continuous reefs. In the Andaman and Nicobar Islands, subject to the rough weather of the south-west and the north-east monsoons, the species is found along the east and west coasts of these islands, but where the coasts are protected from the effects of the monsoons by large inlets of the sea and hills in the path of the monsoons the species is rather rare. The islands of the Nicobar group which receive a heavier rainfall than those of the Andaman group have a relatively denser population of *T. niloticus*. Even after six continuous years of fishing the Nicobars are still the more prolific area than the Andamans, and have yielded a bigger tonnage of shells. As has been observed by Moorhouse (1932, pp. 146-147) in the Low Isles, the species avoids sandy and muddy places along the coasts.

The difficulties of observing the habits of this animal both in its natural haunts and when kept in captivity in aquaria have been explained above. On one occasion (8-1-35) while searching for examples of small size on a wide stretch of coral shingle in Murdakhari Bay, Port Blair (pl. I, fig. 1) a specimen was found crawling slowly on a branch of coral covered with growths of algae, and on observing with a magnifying lens was found to be feeding. The contractions and movements of the foot are extremely slow and suggest those seen in slow-motion films.[1] The respiratory siphon, which is partially closed while in water, seems to open out when the animal is removed from water so that the pallial cavity is in communication with the outside atmosphere. The proboscis-like part of the head which is mobile is extended slowly downwards over the front part of the foot to the surface on which the animal

[1] Robert, A. (1903) described the undulatory movements of the integument of the foot in *Trochus*.

crawls until the aperture of the mouth is closely applied to it. Moorhouse's observation that a small, very short, and non-retractile muzzle is present is not in accord with mine. Then the parts surrounding the aperture are presumably depressed to form a shallow cup in which a partial vacuum may be formed. The contractions of the integument round the aperture and the adjoining parts suggest the formation of a partial vacuum. All the particles of sand and disintegrated coral, and the minute growths of algae on the branch of coral are presumably sucked into the buccal cavity. At the same time the radular teeth appear to assist in rooting out the algal filaments from their attachment. At brief intervals the proboscis-like part of the head is removed from the surface of the coral on which the animal crawls, and on the slightest disturbance in its vicinity, is withdrawn into the shell, followed by the foot, the two sides of which fold along the median line. Examination of the gut contents of a large number of individuals of *Trochus niloticus* from various localities shows that brown and green algae, chiefly the minute species, form part of its food. As the animal feeds by scraping the rocks and coral masses on which it lives, the contents of the gut include a large proportion of inorganic and organic debris, and a variety of organisms which live amidst the algal vegetation. Thus, in the course of the examination of the gut-contents, remains of small Crustacea such as Copepods, Ostracods and Isopods, tests of Foraminifera and Radiolaria, spicules of Sponges and Alcyonaria, fragments of Hydroid colonies, small Polychaete worms, Nematodes, small Molluscs (soft parts as well as shells), Pycnogonids, Insect-larvae (Chironomidae) and demersal eggs of fish have been found in addition to bunches or fragments of leaf-like or filamentous algae including young and immature forms of *Ulva*, *Polysiphonia*, *Chaetomorpha*, *Turbinaria*, *Hypnea*, *Lyngbia*, *Neomeris*, etc.[1] The commonest alga found in the gut of *T. niloticus* was a *Hypnea* sp., pink in colour. According to Yonges's (1928) classification of the feeding mechanisms in the Invertebrates, *T. niloticus* should belong to his section B of group II in which the feeding mechanism is intended for scraping and dealing with large particles or masses, but judging from the contents of the gut, *T. niloticus*, which seems to swallow large quantities of bottom deposits also, may therefore be included in his section A as well. In the rectal portion of the hind-gut, in addition to the inorganic debris in the faecal matter algae in a more or less undigested state are also found. The anterior loop of the rectum contains a soft muddy mass including a few algal filaments and inorganic matter, while the posterior loop contains a somewhat friable mass of debris consisting of large grains of sand and other inorganic material, bunches of undigested algae, and the hard remains of Foraminifera, Sponges, Hydroids, Crustacea, and Mollusca. This fact coupled with that of the absence of food material in the oesophageal part of the fore-gut seems to indicate that the passage of the food through the entire gut is fairly rapid and that digestion is only partial. In some specimens dissected soon after capture the stomach

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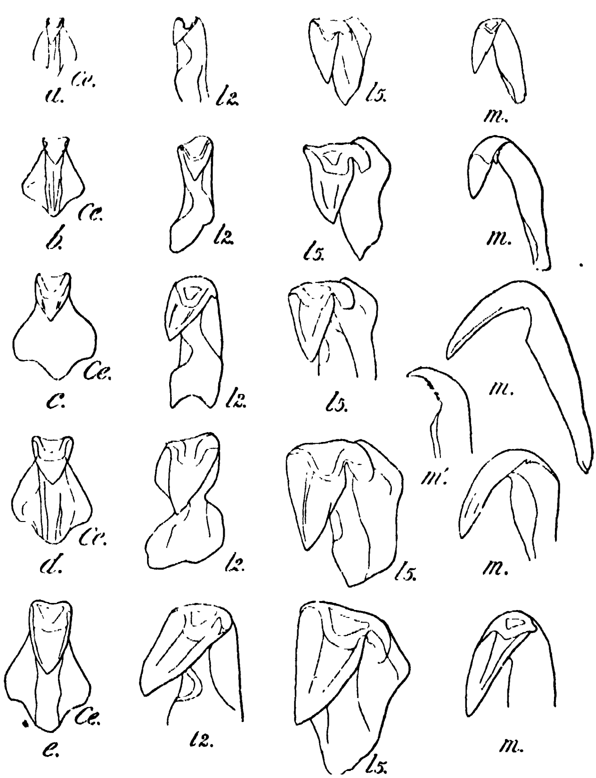
[1] I have to thank my friend, Prof. M. O. P. Iyengar, Director of the University, Botanical Laboratory, Madras, for the identification of the algae.

was found to be empty, while the loops of the hind-gut were full of partially digested matter. The weight of the stomach-contents including the algae and the inorganic and organic debris is very small in proportion to the weight of the entire animal excluding the shell. In fresh specimens of *Trochus niloticus* examined, the weight of the algae alone (separated from the debris) was 6-10 per cent. of the weight of the stomach contents while the organic and inorganic debris constituted over 90 per cent. of the total weight. The weight of the entire animal (including a large quantity of sea-water in the tissues and amongst the internal organs) was 32 times the weight of the contents of the stomach, while that of the shell (usually varying from 3 to 14 ounces) was 2·25 times



TEXT-FIG. 1.—Radular teeth of individuals of *Trochus niloticus* with shell-diameter not exceeding 5·0 cms. (The entire teeth have not been drawn in all cases owing to the high magnification).

a. 1·74 cms.; *b.* 2·32 cms.; *c.* 3·27 cms.; *d.* 4·30 cms.; *e.* 5·00 cms.

ce. central; l_2. second lateral; l_5. fifth lateral; *m.* marginal; m^1. marginal slightly tilted to a side.

the weight of the animal. It would appear that *T. niloticus* extracts its nourishment mainly from the bottom deposits consisting of organic and inorganic material but supplements it with nutriment derived

from an inconsiderable proportion of vegetable matter.[1] This species may therefore be classed as a " selective deposit-feeder ".[2] Although species of *Trochus* are known to be herbivorous and selective deposit-feeders, they occasionally seem to adopt carnivorous habits. Robert (1903, p. 10) recorded that in an aquarium at Roscoff in which *Trochus conuloides* and two specimens of *Palmipes membranaceus* L. Agassiz (slightly injured by the fishing gear) were kept, the former had attacked and devoured the latter in about two days.

The nature of the food of *Trochus niloticus* and the manner of feeding involve a considerable wear and tear of the radular teeth, and the very long radular sac and ribbon seem to meet the constant need for replacing the worn out teeth. The features of the radular teeth of *T. niloticus* are figured by Troschel (1879), but his figures seem to represent those of a much worn series. The marginals, however, seem to be from a different row in that the main cusp and the denticulations are fairly sharp and well-defined. In the series of camera lucida drawings of radular teeth (text-figs. 1 and 2) (central, 2nd and 5th laterals, and the marginal) from approximately the middle region of the ribbon of individuals with shell of diameter 1·74 cms. to 11·14 cms., the features of the radula are shown. The proportions in dimension between the cusps and the basal part remain the same except for slight individual variations. In older individuals there is a tendency for the cusps of the central to become blunt, and for the reduction in the number of small cusps on the marginals. The radular sac is bifid in its terminal portion as in *T. lineatus* (Da costa), *T. magus* (Linn.) and the other species of the sub-genus *Gibbula*, and the radular teeth resemble in structure those of *T. lineatus* (*vide* Randles, 1905), the first marginal not being different in size and structure from the rest of the marginals.

It is a well-known fact that the sexes are separate in *Trochus niloticus*, but no feature in the external form of the shell or in the visible soft parts of the animal when extended gives a clue to the sex of an individual. The differences in the curvature of the whorls and the basal part and in the thickness of the shell met with in the three types of shell-form mentioned above (p. 47) led me to examine the gonads of several individuals belonging to the three types, but no correlation between sex and type of shell was found to exist, that is to say, all three types of shell had male and female elements, thereby establishing that the sex of a given individual cannot be determined at a glance by examining its external features. Moorhouse (1932, p. 146) found no difference in shell-form in the two sexes. Amirthalingam (1932, pp. 72-73) claimed, however, that the outlines of the cavities inside the shell of over 7 cms. diameter as revealed by longitudinal sections " passing through the extreme end of the suture of the outer lip to the bodywhorl and the columella " showed significant differences in the two sexes. In the

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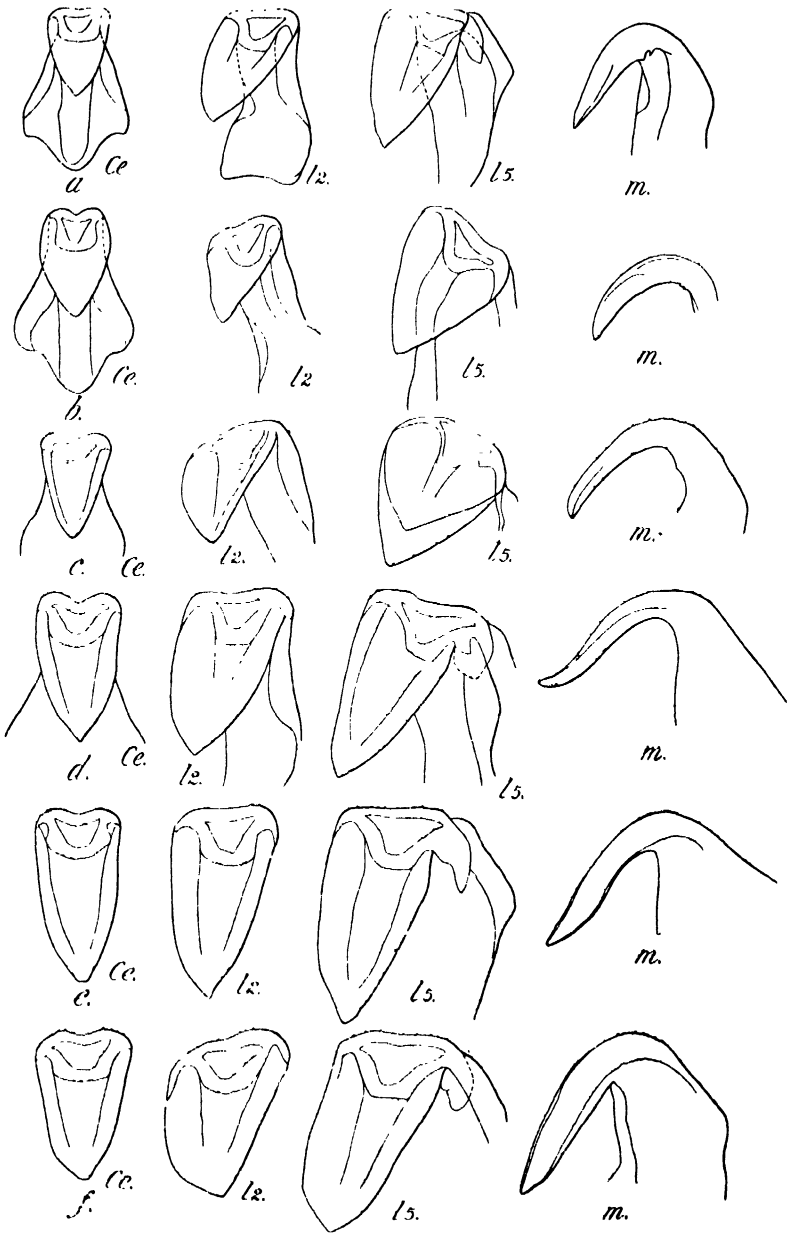
[1] Several specimens of *Turbo marmoratus* from the Andamans showed that their feeding habits were similar to those of *Trochus niloticus*,

[2] Hunt (1925) in the course of his study of the food of the bottom fauna of the Plymouth Fishing grounds found that *Turritella communis* and *Aporrhais pes-pelicanis* (among the various Gastropods present) had roughly sorted bottom material in their stomach.

determination of the sex of a shell at a glance his claim, if confirmed, will have little practical application. No accessory organs indicative



TEXT-FIG. 2.—Radular teeth of individuals of *Trochus niloticus* with shell-diameter above 6·0 cms. and below 12·0 cms. (The entire teeth have not been drawn in all cases owing to the high magnification).

a. 6·70 cms.; *b.* 7·29 cms.; *c.* 8·72 cms.; *d.* 9·69 cms.; *e.* 10·12 cms.; *f.* 11·14 cms. *ce.* central; l_2. second lateral; l_5. fifth lateral; *m.* marginal.

of sex are present in the animal, but when the latter is extracted from the shell, or the spire of the shell is broken exposing the visceral coil, the colour of the gonads in sexually mature individuals, which is dark-green in the female, white or cream in the male, helps in the identification of sex. In immature individuals the portion of the visceral coil representing the gonad is of a more or less uniform gray colour which renders identification of sex difficult, but examination under the microscope of the contents of the gonad either in fresh smears or in sections usually reveals spermatozoa or oocytes in various stages of development. In examples with a shell diameter of less than 3 cms. in which the gonads are still in an undifferentiated state even microscopic examination may often fail to reveal the sex (see text-fig. 6, p. 63). Moorhouse (1932, p. 153) in stating that " in no case were sperm and eggs found together " apparently expected to find sex-change in *T. niloticus*, at any rate, in moderately young *Trochus*. From an examination of a large number of microtome sections of the gonads of both sexes of all ages, I consider that no sex-change is probable, although as Moorhouse suggests the matter requires further examination. A practicable method of examining the sex-products at different stages of the growth of individuals without causing material injury to the animal may help to solve the question of sex-change in *T. niloticus*. At a point three or four whorls below the apex of the shell a tiny hole was made on a few shells with the help of a drill, and the sex-products drawn into a hypodermic syringe through a small puncture in the integument of the gonad were examined on a slide. The specimens thus punctured were returned to the sea, but were recovered dead after a few weeks. A second attempt to examine sex-products by this method resulted again in the death of the animals under observation. A satisfactory method of closing hermetically the puncture in the shell after a sample of the sex-products has been drawn would perhaps eliminate the chance of death of the animals. In the course of the examination of the gonads of several hundred examples of *T. niloticus*, there was no single instance in which sex could not be determined in microtome sections of the gonad of examples with a shell-diameter exceeding 3 cms., and no case of hermaphroditism comparable to that of *Patella vulgata* (see Orton, 1928, pp. 853-857) was observed in *Trochus niloticus*. Even in the former species instances of hermaphroditism appear to be the exception rather than the rule.

Samples of *T. niloticus* having a shell-diameter above 5 cms. from various localities in the Andamans from which smears of the gonads were examined microscopically showed that those having a shell-diameter under 7·0 cms. were usually immature, and that the sexes, were present in almost equal numbers. Shells having a diameter of 7·0 cms. and above were therefore considered adult. The records of the frequency distribution of shells of various adult size- or age-groups of both sexes from various localities in the Andamans lend support to the view that the proportions of males and females are about equal. For the purpose of the investigation of sex-ratio in *T. niloticus*, the records of sizes and sexes of shells collected from two separate groups of islands in the Andamans were selected for study. Dr. K. C. K. E. Raja

to whom I am indebted for the statistical treatment of the records, has kindly furnished the following note :—

Ritchie's Archipelago.

A sample of 806 shells of *T. niloticus* was obtained. Of these 309 were picked up at random and were examined for sex giving the following frequency distributions :—

Age. (Size in centimetres.)	Frequency. Male.	Frequency. Female.
7— 7·99	42	40
8— 8·99	64	57
9— 9·99	25	30
10—10·99	14	16
11—11·99	10	11
	155	154

Taking these two samples of 155 and 154 shells as random samples,

$\chi^2=1{\cdot}086$

N=4, P lies between 0·8 and 0·9.

Hence there is no reason to assume that the numbers of males and females at each size- or age-group are different from each other.

The same problem may be approached from another point of view. We have a larger sample of 806 shells and the assumption that the sexes are equally represented may be tested by comparing the actuals for males and females given above with the expected numbers at each age period, if the totals of 155 and 154 are distributed in the proportions given by the sample of 806.

Age.	Male.		Female.	
(Size in centimetres.)	Observed.	Expected.	Observed.	Expected.
7— 7·99	42	39·61	40	39·36
8— 8·99	64	70·58	57	70·12
9— 9·99	25	25·77	30	25·60
10—10·99	14	13·46	16	13·37
11—11·99	10	5·58	11	5·55

Males.—$\chi^2=4{\cdot}303$, N=4, P lies between 0·5 and 0·3.

Females.—$\chi^2=9{\cdot}091$, N=4, P lies between 0·1 and 0·05.

Hence, in both cases, no significant difference between the expected and observed distributions has been made out.

Cinque, Passage, Sister, Brother and Little Andaman Islands.

In the case of these islands a larger sample of 2,031 shells was available. From this sample a smaller sample of 363 was taken at random

and an examination for the sexes was carried out. The distributions are given below :—

Age.	Male.	Female.
7— 7·99	17	21
8— 8·99	36	30
9— 9·99	33	40
10—10·99	30	41
11—11·99	30	27
12 and over	25	33
	171	192

For the sake of comparability of these figures with those for Ritchie's Archipelago, we leave out the last group (12 and over). A comparison between these two distributions shows that there is no significant difference.

$\chi^2=2{\cdot}952$, N=4, P lies between 0·7 and 0·5.

Further, a comparison between the observed and expected frequencies on the proportions given at each age by the large sample of 2,031 also brings out that there is no significant difference in the case of both sexes.

Males.—$\chi^2=1{\cdot}596$, N=4, P lies between 0·9 and 0·8.

Females.—$\chi^2=10{\cdot}076$, N=4, P lies between 0·05 and 0·02.

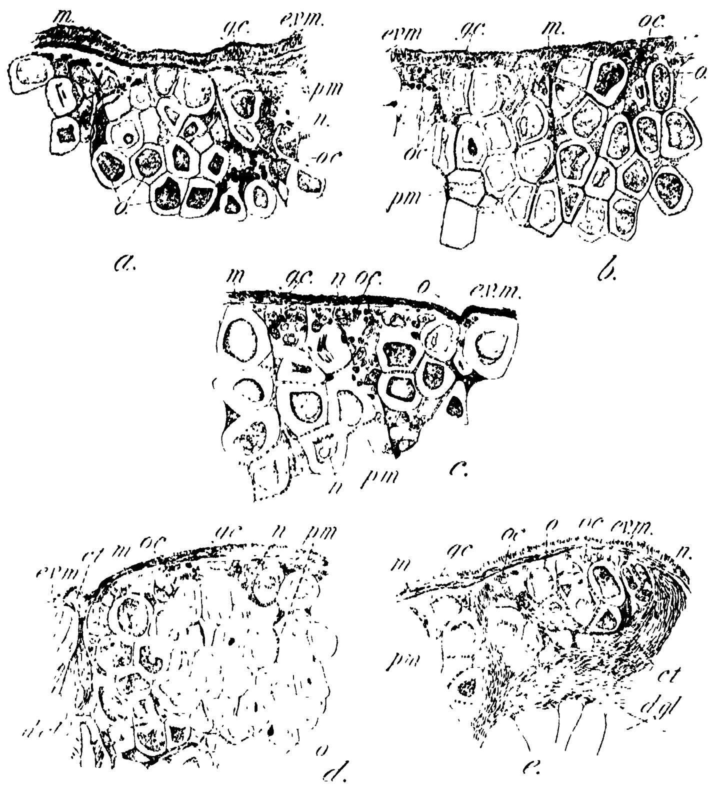
The last result suggests that the difference between the two distributions is just emerging into significance. Taking all the tests into consideration it may be said that males and females appear to be present in about equal numbers at the respective ages. It may be remembered that we have confined ourselves to the ages represented by the sizes from 7—7·99 to 11—11·99. At the later age groups the divergence between the sexes seems to be significant.

In the two samples the bulk of the shells fell into these groups. In both, shells below 7·0 cms. do not come into consideration, as the sex elements are immature at this stage. Above 11·99 cms., there were in the first sample only 0·25 per cent. shells and in the second only 9·80 per cent. The samples represent almost complete collections of the shells in two separate areas and they may be taken to be representative samples of the adult population of *T. niloticus* of these islands. On the information afforded by these samples the inference is that, within the age groups indicated, males and females may be present in about equal numbers.

The conclusions of Moorhouse in regard to the sex-ratio of *T. niloticus* in the Low Isles are thus corroborated by my own observations in the Andamans.

The correlation between age and size in *Trochus niloticus* as indicated by the maximum diameter of the shell has been referred to in a previous paper (Rao, 1936). The determination of the criterion for maturity in both sexes, and of the minimum size or youngest age at which such maturity is reached must precede that of the breeding period. After examining the smears of the sex elements of a large series of examples of all ages from different localities, it was decided that the presence of active

spermatozoa in the male and the size of ova with a diameter between 0·20 and 0·25 mm. (excluding the pitted gelatinous outer cover-



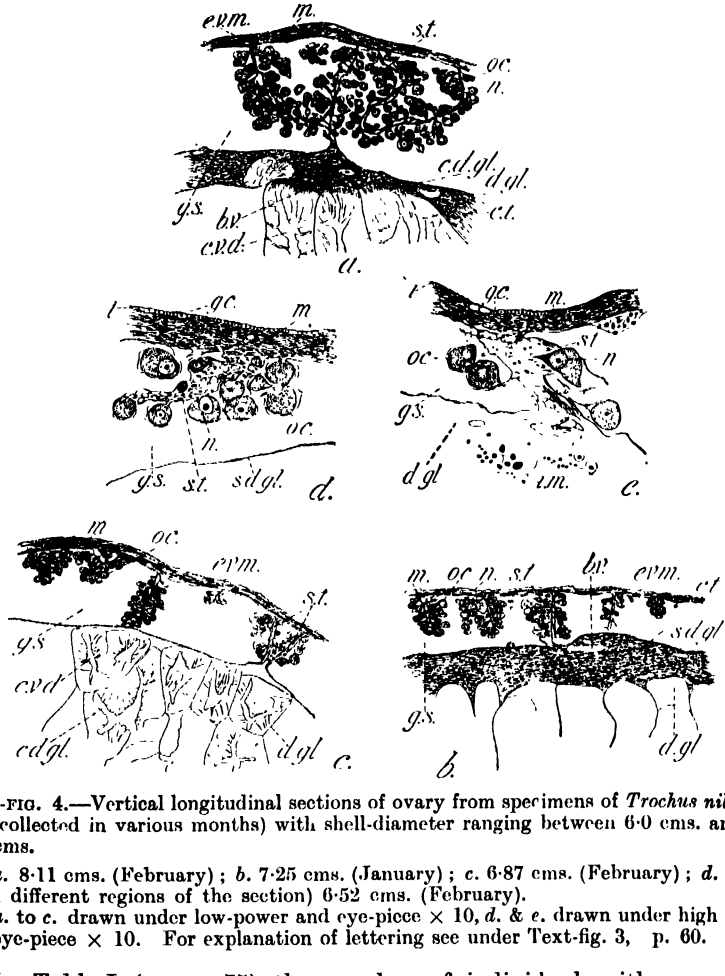
TEXT-FIG. 3.—Vertical longitudinal sections of ovary from specimens of *Trochus niloticus* (collected in various months) with shell-diameter ranging between 9·0 cms. and 12·5 cms.

a. 12·25 cms. (March); *b.* 11·72 cms. (January); *c.* 10·38 cms. (November); *d.* 9·93 cms. (November); *e.* 9·02 cms. (January). (Drawn under low power and eyepiece × 10).

bv. blood-vessel; *c. d. gl.* cells of the digestive gland; *c. i.* cellular inclusions tinted blue by Mallory's stain; *c. t.* connective tissue; *c. v. d.* cavity of the tubule of the digestive gland; *d. gl.* digestive gland; *d. p.* dark pigment; *e. v. m.* epithelium of visceral mass; *g. c.* globular or cubical mucus cells of the integument; *g. s.* coelomic space between the gonadial layer of the epithelium of the visceral mass and the digestive gland; *i.* integument; *i. m.* irregular masses in cells of the digestive gland which take a deep blue tint in Mallory's stain; *m.* muscles of the integument; *n.* nucleus of oocytes; *o.* ova fully developed; *o. c.* oocytes; *o. g.* spherical inclusions (with granules) which stain olive-brown or olive-green in Mallory's stain; *p. m.* pitted membrane; *s. d. gl.* gonadial surface of the digestive gland; *s. t.* branching trabeculae of the coelomic epithelium (lying between the integument and the connective tissue of the digestive gland) with developing oocytes; *t. d. gl.* tubules of the digestive gland; *t. s.* transparent spherical inclusions with olive-yellow granules.

ing) in the female should be the criteria for sexual maturity. In the latter sex the presence of developing oocytes with a diameter ranging from 0·05 to 0·20 mm. rendered the determination of sexual maturity somewhat difficult. It was, however, found later that the development of a pitted membrane round the ova roughly coincided with their maturity, and that in sexually mature females of all sizes there was always

a varying number of oocytes also. For the purposes of a rough and ready method of determining the state of maturity of females smears in which a majority of the number of ova had a diameter exceeding 0·20 mm. were taken as samples representing mature females, and those in which the majority of ova had diameter above 0·05 mm. and below 0·20 mm. were treated as samples representing immature females.



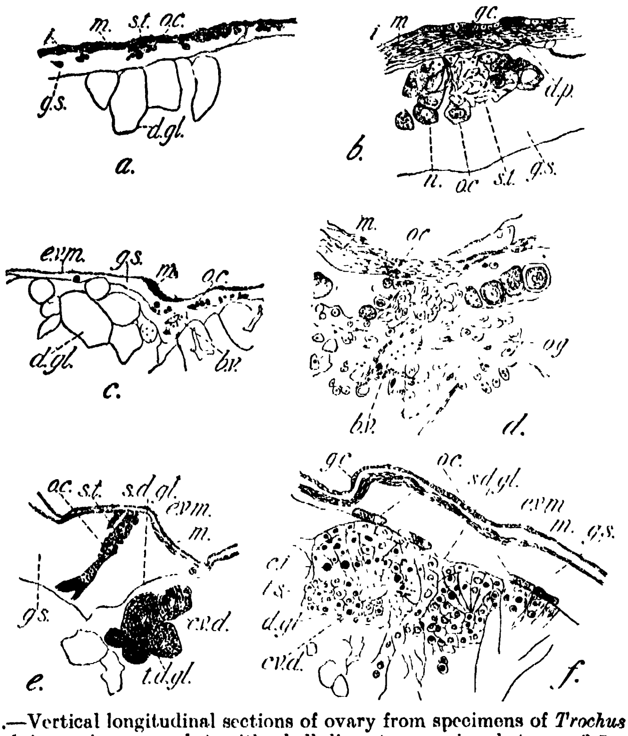
TEXT-FIG. 4.—Vertical longitudinal sections of ovary from specimens of *Trochus niloticus* (collected in various months) with shell-diameter ranging between 6·0 cms. and 8·5 cms.

a. 8·11 cms. (February); *b.* 7·25 cms. (January); *c.* 6·87 cms. (February); *d.* and *e.* (from different regions of the section) 6·52 cms. (February).

a. to *c.* drawn under low-power and eye-piece × 10, *d.* & *e.* drawn under high power and eye-piece × 10. For explanation of lettering see under Text-fig. 3, p. 60.

In Table I (see p. 75) the number of individuals with ova and/or oocytes of the three categories of dimensions, and the total number of shells from each locality examined are shown at the bottom. The percentage frequency of individuals of each size or age-group under each of the three categories of ova-size is shown in the vertical columns of the table. A careful scrutiny of this table would show that in all the localities, 95—100 per cent. of the individuals with a shell-diameter above 10·00 cms. have a majority of fully mature ova, while over 50—90 per cent. of the individuals with a shell-diameter of 9—9·99 cms. have a majority of mature ova. In the individuals of the age-groups with a diameter below 9 cms. the percentage frequency of individuals with mature ova

is reduced to an average of about 33. The examination of the condition of the gonads in a large series of females of all age or size-groups as revealed by microtome sections also brings out the fact that individuals with the shell-diameter below 9·0 cms. have as a rule the gonad in the form of an arborescent racemose gland (Text-fig. 4) while those with the shell-diameter above 9·0 cms. have a relatively large majority of mature ova covered with a pitted gelatinous membrane and arranged in the form of a honey-comb (Text-fig. 3). The proliferation of oocytes on the branching trabeculae of the coelomic epithelium which lie between the integument and the connective tissue of the digestive gland seems to be an invariable feature of the gonads in individuals with a shell-diameter exceeding 9·0 cms. The text-figures (3 to 6) illustrate clearly what has



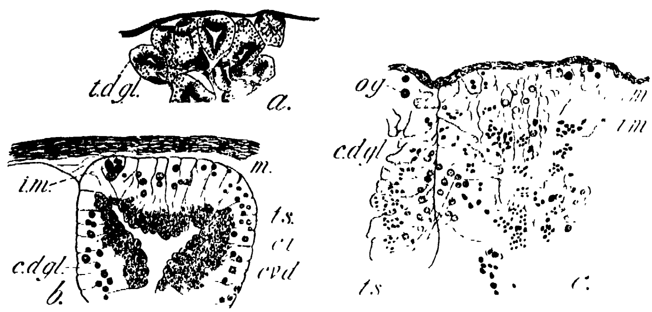
TEXT-FIG. 5.—Vertical longitudinal sections of ovary from specimens of *Trochus niloticus* (collected in various months) with shell-diameter ranging between 3·5 cms. and 5·7 cms.

a. 5·70 cms. (December); drawn under low power and eye-piece × 10; *b.* same as *a.* but with the portion of the section marked *s. t.* and *o. c.* enlarged and drawn under high power; *c.* 4·47 cms. (December) drawn under low power and eye-piece × 10; *d.* same as *c.* but with the portion of the section marked *m.*, *o. c.*, and *b. v.* enlarged and drawn under high power; *e.* 3·55 cms. (January) drawn under low power and eye-piece × 10; *f.* same as *e* but from a different portion of the section and drawn under high power.

For explanation of lettering see under Text-fig. 3, p. 60.

been said above. The inference that in the Andaman waters the female of *Trochus niloticus* becomes sexually mature when it has attained a shell-diameter of 9·0 cms., which as stated in my previous paper (Rao, 1936, p. 482) will be in its third year of life, seems to be justified.

Although no detailed observations on the maturity of the male of *T. niloticus* were made, it was found that individuals with a shell-diameter of 6—7 cms. had generally mature or active sperms in their gonad. The age at maturity of *Trochus niloticus* does not appear to be uniform in all the regions in which the species has been studied. Montague (1915) concluded from his observations in New Caledonia that individuals of *T. niloticus* with shell-diameter above 8·5 cms. (about 3 years old) were mature, while Moorhouse (1932, pp. 154-155) basing his observations on *Trochus niloticus* of the Low Isles came to the conclusion that they were mature in their second year of life when the shell-diameter was generally between 5·00—6·25 cms. Moorhouse found that a few female specimens between 4·40 and 5·00 cms. in shell-diameter were also sexually mature. The range of shell-size for sexual maturity among males was according to him between 5·61 and 7·22 cms. in diameter. The results of my observations are more in accord with those of Montague. Whether the differences in the age at maturity in the three areas have anything to do with the differences in the environmental conditions such as temperature, food, salinity, etc., cannot be stated without further observations[1]. Orton (1922, pp. 351-353) gives several instances of the attainment of sexual maturity at a very early age under suitable temperature conditions, and points out that size or age at maturity will depend on the duration of growth and breeding, and that in favourable breeding conditions development of the gonads at an early stage of growth takes precedence over mere increase in size. The comparatively early attainment of maturity by *T. niloticus* in the Low Isles is presumably to be attributed to favourable temperature or other conditions which in the case of New Caledonia and the Andamans seem to be lacking, or as Moor-



TEXT-FIG. 6.—Vertical transverse sections of the digestive gland of specimens of *Trochus niloticus* (collected in July) with shell-diameter ranging between 2·5 cms. and 3·5 cms. The sections indicate no trace of the ovary in the space between the integument and the digestive gland.

a 3·17 cms. (drawn under low power and eye-piece × 10); *b*. a portion of the same section drawn under high power. *c*. 2·73 cms. (drawn under high power and eye-piece × 10).

For explanation of lettering see under Text-fig. 3, p. 60.

house himself surmised, the occurrence of maturity in small-sized shells may indicate a retardation in the growth of the shell.

[1] The recent works of Newcombe (1936), and of Newcombe and Kessler (1936), on the relationship of growth and environment in the clam, *Mya arenaria* Linn. deal with these questions in some detail.

The rate of growth at different ages has been dealt with in a previous paper (Rao, *loc. cit.*). Despite the fact that shell-growth is very irregular even in the individuals of a given size-category, there is a definite falling off in the rate of growth as the shell increases in size. Moorhouse speaks of " a definite slackening off in the amount of shell deposited by the animals during the colder months ", and of a period of " rest from shell-building " which he terms the " time of hibernating ", but in the Andamans I have not been able to obtain any evidence to show that *T. niloticus* has a slack season for growth of shell or a definite period of aestivation when the animal does not feed or move about. Amirthalingam's (1932, p. 98) observations on the growth of *T. niloticus* at Port Blair led him to the conclusion that it " grows during the monsoon and 'winter' months, that is, July to March ", a statement which seems to imply that the remaining part of the year from April to June constitutes a season of slow or no growth.

The determination of the breeding period or periods of *T. niloticus* in the Andamans presented considerable difficulties. The main criterion for breeding is the discharge of eggs and spermatozoa at about the same time, and the fertilisation of the former leading to development. Observations in the field and in the laboratory of several hundreds of adult sizes of *T. niloticus* during the years 1932 to 1935 failed to reveal any male or female in the act of discharging its sex-products. Artificial fertilisation experiments with the ripe sex-products obtained from individuals having a shell-diameter of 10·0 cms. during the months September to July proved a failure.[1] The mature state of the sex-products of the adults throughout the year seemed to show that at any time of the year individuals bearing ripe sex elements were not altogether absent. Amongst them were those with gonads full of ova or spermatozoa as well as individuals (with flabby gonads) which may be considered to have recently shed their sex-products in part. A second method of approach to the problem of the breeding season adopted was the periodical examination of the plankton of the inshore waters round about Port Blair and other localities to discover the occurrence of any advanced veligers with shell resembling the types common to Trochidae. Several forms allied to the Cerithidae, Rissoidae, Turbinidae, Neritidae, etc., were found in the plankton during the warmer months of the year, and it was thought that the occurrence of advanced larvae of Trochidae would give a clue to the breeding period. Unfortunately, none of the Trochoid forms was obtained during the months December to April when the weather conditions were suitable for the collection of plankton.

If breeding in *T. niloticus* were confined to a short season in the year one would expect to find the shell-populations distributed in several sharp well-defined categories of sizes. Supposing that the breeding season was spread over a period of 2—3 months only commencing in April, and a random sample of the population in a given area measured, say in March of the following year, one would find only shells with a diameter

[1] The looseness of the ova in the gonads which washed freely when a jet of water was directed on it, and the presence of ova in the passages connecting the gonad with the kidney were taken as the criteria for judging the readiness of specimens to breed. The impurity of the sea-water in the shore area around Port Blair which had to be used for the experiment was probably responsible for the failure of artificial fertilisation.

of about 5 cms. in the first year of growth, of 8 cms. in the second year of growth, of 10 cms. in the third year of growth and so on exhibiting gaps in size between the various groups, but none amongst the size-ranges of 1—4 cms.[1] In fact, however, the data of shell-collection of *T. niloticus* round about Port Blair for a period of 4 years ending in July 1935 show no well-defined gaps in the distribution of shells amongst the various categories of sizes (see Table II, pp. 76-79). The absence of small-size shells of diameter upto 1·99 cms. in the years 1931-34 has no significance. Because of their cryptic habits and small-size, and the dull colour of the shell which so well harmonizes with that of its surroundings, the small shells may have been overlooked.[2] The intensive fishing for *Trochus* shells by the Japanese during the years 1929 and 1930, may have also been partly responsible for the scarcity of both the small and the very large shells with a diameter range of 1-3 cms. and 12-14 cms. respectively. A glance at Tables II and III (pp. 76-79 and p. 80) would seem to emphasise the point that intensive collection has made inroads on the large-sized shells as the frequency distribution of shells of various sizes in the four years 1931-35 shows. The mode of frequency seems to move gradually from 7·0 and 8·0 cms. categories in 1931-32 to 3·0 and 4·0 cms. categories in 1934-35.

Of the three types of evidence available for determining the breeding period, that provided by the larvae is negative. The mature and gravid condition of the gonads in adult individuals throughout the year leads one to the conclusion that breeding is not noticeably interrupted, while the samples of shells, collected throughout the twelve months of the four years in the same locality, which include shells of all ages amply support the conclusion that breeding is continuous (see Tables II and IV, pp. 76-79 and p. 81).

In the Low Isles, Moorhouse (1932, p. 154) observed that the spawning period was of some five months' duration at least, commencing in March, and that eggs were liberated not in great clouds but in small quantities at a time. He thought however that the egg-laying was protracted over a period longer than five months. In New Caledonia Montague (*loc. cit.*) found in the month of December several sepecimens (9 cms. in diameter) distended with eggs ready for deposition. In the Andamans, Amirthalingam (1932, p. 31) inferred that spawning would probably begin in April, presumably from the fact that females with spent gonads were observed from that month onwards, but did not mention whether he had seen any individuals actually spawning. If spawning is continuous over only a short period, one may expect to find a majority of individuals with spent gonads during that period. Actually, however, examples with full and spent gonads were obtained during the warm as well as the cold months of the year. These terms ' warm ' and ' cold ' have relatively less significance in the latitudes in which the Andamans

[1] The results of the rate of growth studies embodied in another paper (Rao & Raja, 1936) have been used to estimate the age-groups.

[2] It is also possible that the younger forms inhabit the deeper parts of the sea from which a few stray into the shallower parts and the intertidal region. Hedley (1917, p. 70) stated that the youngest stages of *T. niloticus* are passed in deep water on the reefs. Gopala Aiyar (1935) found that specimens of the Echinoid *Salmacis bicolor* of small size (3-4 cms. in diameter) were singularly absent amongst hundreds of large forms obtained from the Madras Harbour, and suggested that the young forms may probably be confined to the deeper parts, creeping up only after attaining maturity.

are situated where the annual range of the average monthly temperature of the surface-water does not exceed 2° C.[1] The influence of temperature on breeding is discussed below. It may be pointed, however, that in the Andamans there is no definite evidence to show that spawning is confined to any well-marked season, although spawning has probably a tendency to be more intensive in the warm months from February to May, than during the monsoon months June to November.

The temperature observations on the east coast of Ross I. were taken at various hours of the day from 6 A.M. to 6 P.M. in knee-deep water between the rocks constantly washed by the waves. The highest and lowest temperatures recorded during these nine months were 32·0° C. in May and 25·9° C. in December respectively, while (the daily average) high temperatures prevailed during the months of May and October. The average temperature for April would presumably be higher than that of May, but owing to other work no observations could be taken at Port Blair during the dry and warmer months of February, March, and April (see Table V, p. 82).

Amirthalingam in his note to *Nature* (p. 98, 1932) stated that *Trochus niloticus* " has a minimum temperature above which alone it would spawn " basing his conclusion presumably on the fact that individuals with spent gonads were found from the month of April onwards, and on the results of Sewell's temperature observations (*loc. cit.*) in the Andaman sea which indicate a double oscillation in temperature in the course of a year. He also stated that the observation that *T. niloticus* starts spawning in April when the first rise of temperature takes place emphasised " the idea that the marine invertebrates in tropical waters do not breed haphazardly but with a similar regularity to that observed in temperate waters ". My observations in the Andamans for about 3 years do not establish any definite correlation between breeding in *T. niloticus* and the observed high temperature epochs of the Andaman sea, and the analogy of the correlation between these two phenomena in the temperate seas may not hold good in the tropics.[2] Recently Whedon (1936) studying the spawning habits of *Mytilus californianus* Conrad in the vicinity of San Francisco with reference to temperature doubted that the changes in temperature which occur in that region were severe enough to influence spawning. He found the sex products developing in the warmer months when food was most abundant, and the mussels spawning in the cooler months, while on the contrary *Mytilus edulis* of the Atlantic coast of America was observed to develop sex products in the coldest months and to spawn with the onset of warmer conditions. In the same manner the warmer periods during March and April and again in October in the Andamans may stimulate the activity of sex-glands in *T. niloticus* leading to a comparatively intensive spell of spawning at their end, or during the cooler months following the warm periods.

[1] The average daily range of temperature at Port Blair as given by Sewell (1927, pp. 104-118) seems to be much higher than the one given here. My observations at Port Blair during 1933 show that the difference in maximum and minimum temperatures attained in the course of the day is no more than 2° C.

[2] Adult specimens of *T. niloticus* kept in samples of sea-water the temperature of which was raised by artificial heat up to 35° to 40° C. did not show any signs of spawning, although active movements of the animal were observed.

Orton (1922) has shown that in marine animals of temperate regions sexual activity is induced under normal biological conditions by the stimulus of temperature, and that in the temperate regions the breeding temperature which is a physiological constant for each species of marine animal may be the minimum or the maximum attained in that particular locality. In regard to the tropics where constant or nearly constant temperature conditions prevail, he has stated that " there is apparently good evidence that breeding in marine animals is continuous, but a thorough investigation of this problem is desirable ". The main problems in regard to the breeding of tropical marine animals may be stated in the form of a questionnaire : (1) does the small range of variation in the temperature of tropical seas admit of considering temperature as the main stimulus for breeding, (2) if the answer to this question is in the affiirmative, do the maxima and minima of temperatures attained in various localities act as physiological constants in the breeding of marine animals, (3) do factors other than temperature have any correlation with breeding, and if so, to what extent. In the present state of our knowledge of the breeding of tropical marine animals the answers to the questionnaire would presumably be incomplete. Observations in the different regions of the tropical seas seem to have led to divergent conclusions. A short review of the opinions held in regard to the general question of the epoch and frequency of breeding in the tropical seas may not be out of place here. Mortensen (1921), while admitting that temperature has an important bearing on development which proceeds at a conspicuously quicker rate at the higher temperature of the tropics than in the colder regions, did not agree with the view that all tropical marine animals breed continuously throughout the year. From his experience of some species of tropical Echinoderms he could only concede that they have more than one breeding season in the year. He was able to confirm Orton's statement that " where biological conditions do not vary much marine animals will breed continuously " but " would only object to making this a general rule ; this it is certainly not, especially not in the tropics ", by which Mortensen apparently meant that biological conditions do vary in the tropics and that therefore breeding cannot be continuous. Anne Stephenson (1934), as a result of her observations on the breeding of various marine Invertebrates such as Coelenterates, Echinoderms, Molluscs, and Crustaceans in the Great Barrier Reef in 1928-29, came to the conclusion that the breeding was by no means confined to any one part of the year, but occurred every month, in winter as well as in summer. She believed, however, that although spawning was going on all the year round, a majority of the species investigated " would be found spawning either exclusively or most actively in the warmer months ". She also thought that " the actual breeding season of any one species would probably fluctuate considerably from one year to another, in the same place, not to mention its varying from one district to another ". She observed four main types of breeding in the Great Barrier Reef, (1) a single breeding period not lasting the whole year round, (2) continuous breeding throughout the year but more active in one part of the year than during the remainder, (3) discontinuous breeding occurring in relation to lunar phases during a longer or shorter portion of the year, (4) two spawning periods

in the year with a quiescent phase between them. Moore (1934) observed considerable variation in the breeding periods of *Echinus esculentus* even in localities separated only by a few miles and at different depths. Gopala Aiyar (1931) found the Polychaete worm *Marphysa* breeding in Madras from January to September and again in December. The same author (1935) collected sexually ripe individuals of the Echinoid *Salmacis bicolor* in the Madras Harbour throughout the year at temperatures varying from 24° C. to 30° C., and found (1935) *Acentrogobius neilli* (Day) breeding at all times in the Adyar backwaters, Madras, at temperatures varying from 24°·4 C. to 29°·65 C., but with an intensive breeding period during the monsoon in October and November.[1] Subramaniam (1935) observed the brackishwater hermit-crab, *Clibanarius olivaceous* (Henderson) at the mouth of the Adyar River, Madras, breeding throughout the year but with a well-marked intensive period from September to March. Whedon (1936) found *Mytilus californianus* Conrad in the region of San Francisco spawning at all times of the year, but with a maximum period of spawning beginning early in October, followed by two other periods of lesser degree in January and February, and in May and June. This short review of recent work on breeding in tropical marine animals in relation to temperature changes seems to indicate that the evidence in support of the view that tropical marine animals breed continuously tends to gather weight. It does not seem to be clear, however, what, under the uniform biological conditions of tropical seas, constitute the stimulus for inducing marine animals to spawn. Whedon (*loc. cit.*) has " shown that spawning occurs at all times of the year, apparently irrespective of temperature or other external stimuli ", and the observations of Anne Stephenson (*loc. cit.*) and Moore (*loc. cit.*) seem to lend support to that author's findings.

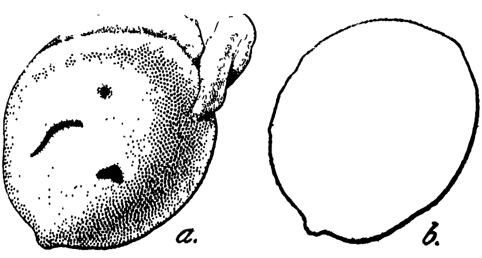
In regard to the factors which influence breeding in *T. niloticus* the observations of Montague (*loc. cit.*), Moorhouse (1932) and Amirthalingam (*loc. cit.*), and those recorded in the present paper tend to show that the physiological constant which induces spawning is not merely temperature or latitude or food. The optimum condition for spawning in a given region would probably be a combination of several factors which may include one or more of those mentioned. Without a detailed investigation of the physiology of *T. niloticus* it would be difficult to determine the factor or combination of factors which induces sexual activity throughout the year. On the whole the question of sexual maturity and spawning in individual species of tropical marine animals in relation to the physical and biological conditions at different latitudes cannot be settled satisfactorily without further knowledge of the habits of marine animals from various regions of the tropical seas.

The longevity of *Trochus niloticus* in the Andamans has been dealt with (Rao, *loc. cit.*) in another paper. Individuals with shell-diameter up to 15 cms. have occasionally been taken in collections from various islands of the Andaman and Nicobar groups. Under normal conditions an individual may live for well over 10 years attaining a diameter of

[1] In the Andamans I have observed the Blenniid fish *Andamia heteroptera* Bleeker on the rocks between tide-marks in the vicinity of Port Blair with fully developed eggs from September to the beginning of May, and young ones 1·2 cms. long practically throughout the year.

over 12 cms., but specimens with shell-diameter exceeding 14 cms. may be 12 years old.[1] Death in *T. niloticus* due to old age is very little known. Certain characters of the shell (in examples with diameter exceeding 11 cms.) observed in the course of the investigation seem to suggest their association with senility. The tendency of the upper margin of the last whorl to be discrete from the suture or the previous whorl, the irregularity of the oblique lines of growth on the last whorl, the thickening of the shell, and the tendency to the formation of blisters on the nacreous surface of the mouth of the shell are some of the features commonly observed in shells above 11—12 cms. in diameter and may be associated with the senile changes in this species. There may be other features of senility exhibited by the internal organs such as the digestive and the nervous systems,[2] but these have not been investigated.

The sheltered positions on the reefs in which *T. niloticus* occurs probably protect the species to some extent from predatory enemies, such as sharks, rays, Gymnodontid fishes, etc. In the more exposed parts of the reefs, however, the extremely thick and hard shell of the species seems to be of doubtful utility in protecting the species from the attacks of such enemies mentioned above, for fragments of shells of *Trochus* and *Turbo* have been found amongst the gut contents of these fish.[3] The thin and weak operculum seems to provide inadequate protection against the attacks of large crabs which with the help of their powerful chelipeds seem to tear the soft parts of *Trochus* in the expanded state. On one occasion a large crab on the reef near South Point, Port Blair, was seen helping itself to morsels of the flesh of *T. niloticus* under a stone when the animal was in a partial state of expansion. The snail was found to be dead, but it was difficult to say whether the crab was merely feeding on the carcass of an individual, or had caused the death of the animal



TEXT-FIG. 7.—Calcareous concretion from the apex of the visceral coil of *Trochus niloticus* from Sister Is., Andamans (24.ii.1933).

a. In the investing membrane which is produced into a short twisted stalk at one end., *b.* The concretion removed from its investment.

prior to feeding on the flesh of its victim. A species of Gastropod (Purpurinae-Muricidae) was also found feeding similarly on the soft

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[1] Hedley (p. 70, 1917) stated that according to native tradition in Fiji, *T. niloticus* lives for 4 years.

[2] For a detailed study of senility among Gastropods the works of Burnett Smith (1905), of I. and M. Szabó (1934) and of I. Szabó (1935) may be consulted with advantage.

[3] Moorhouse (1932, p. 148) recorded that sting-rays, hermitcrabs (*Dardanus megistos*) and whelks were responsible for the destruction of live *Trochus niloticus* on the Low Isles.

7. The feeding habits of *T. niloticus* are described. It is shown that the species lives chiefly on bottom deposits and on fresh algal vegetation. The features of the radular teeth of animals of various ages are described.
8. No certain method of determing the sex of the shell without breaking it open or damaging it is known. The sexes are separate and are distinguished by the colour of the gonads, green in the adult female, white or cream in the adult male. The young male or female can only be distinguished by examining smears of the gonad under the microscope, or by microscopic examination of microtome sections. Hermaphroditism and sex-change have not been observed, and are considered improbable of occurrence.
9. The two sexes occur in about equal numbers in the adult age-groups with shell-diameter between 7·0 and 11·99 cms. This fact is supported by statistical evidence.
10. In the Andamans and Nicobars, sexual maturity is reached in the female when the shell has attained a diameter of 9·0 cms., and in the male when the shell has a diameter of 6·0 –7·0 cms.
11. No evidence of a slack season for growth in shell or of a period of aestivation for *T. niloticus* in the Andamans has been obtained.
12. The mature condition of the gonads and the readiness for spawning which has been observed in adults of *T. niloticus* throughout the year, and the occurrence, during the twelve months of the year, of shells of all ages indicate that breeding is continuous with perhaps an intensive spell of breeding during or immediately after the warm seasons.
13. The opinions held in regard to the problems of the stimulus for spawning, and of the period and frequency of breeding in tropical marine animals are reviewed. The inadequacy of any one environmental factor alone to stimulate sexual activity is pointed out. It is suggested that a more detailed investigation of the physiology of tropical marine animals would provide satisfactory solutions to these problems.
14. The age of *T. niloticus* in the Andamans is shown to exceed 10 years. Certain features in the shell suggestive of senility are described.
15. The incidence of mortality due to diseases or old age is indicated to be low. Animals associated with the shell or the soft parts of *T. niloticus* and causing in some instances damage to the shell are described.

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TABLE I.

Table showing the percentage frequency of individuals with ova of three different dimensions.

Age or size-group (Diameter in cms.).	RITCHIE'S ARCHIPELAGO.			CINQUE, SISTER, BROTHER, PASSAGE AND LITTLE ANDAMAN ISLANDS.			INTERVIEW I. AND OTHER ISLANDS OF THE WEST COAST OF ANDAMAN ISLANDS.			PORT BLAIR AND ENVIRONS.		
	PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA			PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA			PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA			PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA		
	below 0·05 mm.	between 0·05 and 0·20 mm.	above 0·20 mm.	below 0·05 mm.	between 0·05 and 0·20 mm.	above 0·20 mm.	below 0·05 mm.	between 0·05 and 0·20 mm.	above 0·20 mm.	below 0·05 mm.	between 0·05 and 0·20 mm.	above 0·20 mm.
6— 6·99 . . .	..	..	..	100·0	..	..	..	..	..	..	..	..
7— 7·99 . . .	41	59	..	85·7	14·30	..	80	..	20 00	66·6	..	33·3
8— 8·99 . . .	19	46	35	60·0	23·30	16·70	18	32·00	50·00	..	66·6	33·3
9— 9·99 . . .	10	13	77	7·5	40·00	52·50	..	16·42	83·58	11·2	..	88·8
10—10·99 . . .	..	..	100	..	4·88	95·12	..	..	100·00	..	..	100·0
11—11·99 . . .	..	..	100	..	..	100·00	..	1·25	98·75	..	..	100·0
12—12·99 . . .	..	..	..	..	..	100·00	..	..	100·00	..	..	..
13—13·99 . . .	..	..	..	..	..	100·00	..	..	..	..	..	..
Total No. of shells examined	148			192			340			55		
No. of shells in each group	29	51	68	41	28	123	13	28	299	11	6	38

TABLE II.

No. of shells collected at Port Blair in each month of the year **1931-32.**

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1·99	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2— 2·99	..	..	2	..	..	..	..	..	..	..	..	..	2	0·29
3— 3·99	..	..	..	..	1	..	..	..	2	..	..	..	3	0·44
4— 4·99	..	..	..	..	1	..	..	4	10	2	4	2	23	3·36
5— 5·99	..	..	3	2	18	5	..	3	7	2	3	4	47	6·86
6— 6·99	..	..	6	6	37	33	9	5	7	2	4	1	110	16·06
7— 7·99	..	..	6	7	29	39	16	4	4	8	6	2	121	17·66
8— 8·99	..	..	4	9	25	27	10	6	10	12	14	10	127	18·54
9— 9·99	..	..	4	8	19	15	5	6	7	4	9	12	89	12·99
10—10·99	..	..	2	11	17	8	4	6	3	4	19	6	80	11·68
11—11·99	..	..	..	3	6	10	1	4	5	1	23	2	55	8·03
12—12·99	..	..	..	2	2	..	3	5	2	..	11	..	25	3·65
13—13·99	..	..	..	..	..	..	..	..	..	..	3	..	3	0·44
Total No. for each month	..	..	27	48	155	137	48	43	57	35	96	39	685	100·00

TABLE II—*contd.*

No. of shells collected at Port Blair in each month of the year **1932-33.**

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1·99	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2— 2·99	..	..	..	..	..	..	..	..	1	1	1	..	3	1·0
3— 3·99	..	..	..	..	2	2	1	5	1	..	..	1	12	4·7
4— 4·99	..	..	..	..	1	1	1	3	10	3	2	..	21	8·2
5— 5·99	1	1	..	5	8	1	..	..	2	3	8	..	29	11·4
6— 6·99	1	4	..	4	14	16	1	2	1	6	2	..	51	20·0
7— 7·99	1	3	..	6	19	19	2	2	..	2	1	..	55	21·6
8— 8·99	1	1	1	1	5	19	..	..	1	..	2	..	31	12·2
9— 9·99	..	1	..	..	..	6	3	1	2	1	..	..	14	5·5
10—10·99	..	3	2	3	..	5	..	..	1	..	..	..	14	5·5
11—11·99	..	3	..	5	..	5	..	1	2	..	..	..	16	6·3
12—12·99	..	1	1	1	..	6	..	..	..	..	..	..	9	3·5
13—13·99	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total No. for each month	4	17	4	25	49	80	8	14	21	16	16	1	255	99·9

TABLE II—*contd.*

No. of shells collected at Port Blair in each month of the year **1933-34.**

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1·99	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2— 2·99	..	..	5	1	3	6	1	..	..	1	..	..	17	7·26
3— 3·99	2	5	8	4	3	2	1	1	3	4	1	..	34	14·53
4— 4·99	4	10	4	..	1	..	1	..	..	10	..	1	31	13·25
5— 5·99	1	7	..	5	6	2	2	..	..	2	..	2	27	11·54
6— 6·99	..	4	..	7	6	4	3	1	..	4	..	1	30	12·82
7— 7·99	..	1	..	7	1	2	5	5	..	6	..	3	30	12·82
8— 8·99	..	..	..	..	3	1	5	10	..	5	..	3	27	11·54
9— 9·99	..	3	..	..	1	1	5	2	..	2	..	3	17	7·26
10—10·99	..	..	..	2	..	..	2	..	1	2	..	4	11	4·70
11—11·99	..	..	1	4	..	..	..	..	1	..	..	..	6	2·56
12—12·99	..	..	1	1	..	..	..	..	2	..	..	..	4	1·71
13—13·99	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total No. for each month .	7	30	19	31	24	18	25	19	7	36	1	17	234	99·99

TABLE II—*concld.*

No. of shells collected at Port Blair in each month of the year, **1934-35.**

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1·99	..	..	..	..	2	..	1	..	..	..	..	..	3	0·62
2— 2·99	..	1	4	8	5	10	9	5	6	4	9	..	61	12·55
3— 3·99	8	..	4	4	17	16	23	5	24	11	34	11	157	32·30
4— 4·99	11	4	14	3	7	5	9	1	7	4	4	4	73	15·02
5— 5·99	5	5	5	4	7	6	..	2	2	..	2	3	41	8·44
6— 6·99	..	5	6	4	7	1	3	2	..	2	1	1	32	6·58
7— 7·99	..	..	5	4	3	2	2	..	4	6	..	..	26	5·35
8— 8·99	..	6	5	3	1	..	..	5	3	5	1	..	29	5·97
9— 9·99	1	8	2	9	1	1	1	11	2	2	..	1	39	8·03
10—10·99	..	1	1	1	1	..	2	7	1	..	1	..	15	3·09
11—11·99	1	1	..	..	..	1	..	3	1	..	..	..	7	1·44
12—12·99	..	..	..	..	..	..	..	..	..	1	..	..	1	0·20
13—13·99	..	..	..	..	..	..	..	..	..	2	..	..	2	0·41
Total No. for each month .	26	31	46	40	51	42	50	41	50	37	52	20	486	100·00

TABLE III.

Table showing the percentage frequency of shells of the various age-groups collected in the four years, 1931-35 at Port Blair.

Age-groups.	1—1·99.	2—2·99.	3—3·99.	4—4·99.	5—5·99.	6—6·99.	7—7·99.	8—8·99.	9—9·99.	10—10·99.	11—11·99.	12—12·99.	13—13·99.
1931-32 . .	..	0·29	0·44	3·36	6·86	16·06	17·66	18·54	12·99	11·68	8·03	3·65	0·44
1932-33 . .	..	1·00	4·70	8·20	11·40	20·00	21·60	12·20	5·50	5·50	6·30	3·50	..
1933-34 . .	..	7·26	14·53	13·25	11·54	12·82	12·82	11·54	7·26	4·70	2·56	1·71	..
1934-35 . .	0·62	12·55	32·30	15·02	8·44	6·58	5·35	5·97	8·03	3·09	1·44	0·20	0·41

TABLE IV.

Table showing the occurrence of shells of T. niloticus at Port Blair of various age-groups in the twelve months of the year.

Months.	Age-groups.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
May	—	×	×	×	×	×	×	×	×	—	×	—	—
June	—	×	×	×	×	×	×	×	×	×	×	×	—
July	—	×	×	×	×	×	×	×	×	×	×	×	—
August	—	×	×	×	×	×	×	×	×	×	×	×	—
September	×	×	×	×	×	×	×	×	×	×	×	×	—
October	—	×	×	×	×	×	×	×	×	×	×	×	—
November	×	×	×	×	×	×	×	×	×	×	×	×	—
December	—	×	×	×	×	×	×	×	×	×	×	×	—
January	—	×	×	×	×	×	×	×	×	×	×	×	—
February	—	×	×	×	×	×	×	×	×	×	×	×	×
March	—	×	×	×	×	×	×	×	×	×	×	×	×
April	—	×	×	×	×	×	×	×	×	×	×	—	—

× = indicates occurrence.

TABLE V.

Daily average surface-water temperature of the inshore region on Ross I. in degrees centigrade.

Months.	Forenoon.	Afternoon.	Difference in average.
1933—			
May	28·8	29·5	0·7
June	28·1	28·1	0·0
July	27·7	28·5	0·8
August	28·7	29·2	0·5
September	27·9	28·0	0·1
October	28·5	30·4	1·9
November	28·4	29·3	0·9
December	27·5	28·2	0·7
1934—			
January	27·4	28·5	1·1

EXPLANATION OF PLATE I.

FIG. 1.—Murdakhari Bay, Port Blair, Andamans, uncovered by the sea at spring tide. Sand and shingle made up of branches and slabs of Madreporarian coral constitute the region between tide-marks. Small shells of *Trochus niloticus* below 5 cms. in diameter are of common occurrence amongst the shingle.

FIG. 2.—Live specimens of *T. niloticus* in glass aquaria in the Laboratory at Port Blair a few hours after capture. The animal is never fully expanded in aquaria, and shows only the operculum, parts of the foot and the epipodia (½ Nat. size).

FIGS. 3—10.—Shells of *Trochus niloticus* of various age-groups, 5 cms. and below in diameter. The diameters in cms. of shells of the upper row from left to right are 5·00, 4·77, 3·48, and 3·43 respectively, and of shells of the lower row from left to right are 2·32, 2·15, 1·74, and 1·21 respectively (½ Nat. size).

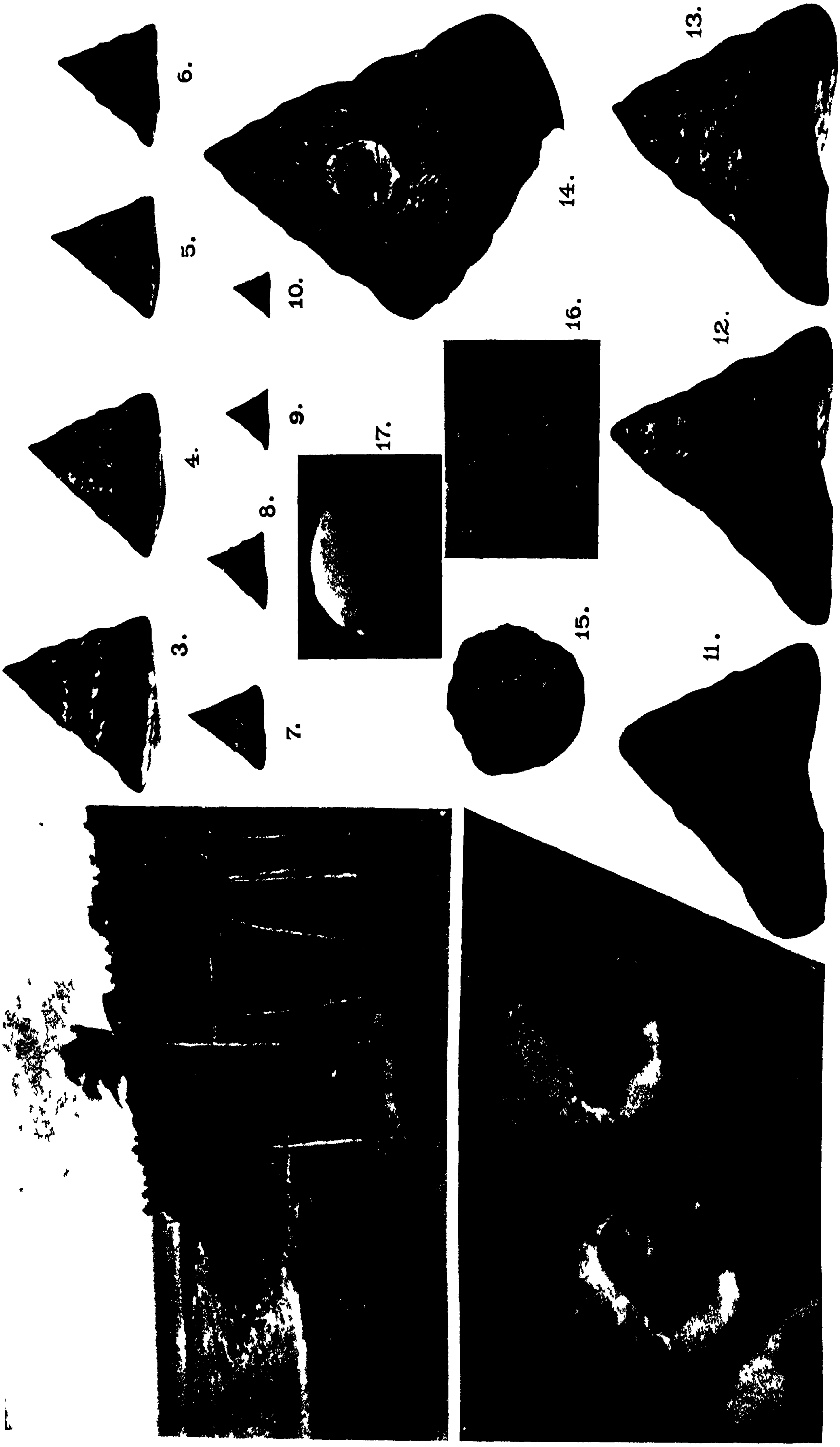
FIGS. 11—13.—Types of shell of *Trochus niloticus* of the 8 cms. category viewed from the side away from the aperture. 11. convex type, 12. flat type, 13. plano-convex type with a peripheral ridge (from N. Andaman, January 1935) (½ Nat. size).

FIG. 14.—Shell of young *T. niloticus* 5 cms. in diameter bearing the scar left by the Lepetellid, *Saptadanta nasika* Prashad and Rao. (Nat. size).

FIG. 15.—Top portion of the spire of *T. niloticus* (bored by a species of *Lithophaga*) as viewed from below, McPherson Strait, Andamans (18.i.34) (Nat. size).

FIG. 16.—A portion of the basal part of the last whorl of a large shell of *T. niloticus* from the Nicobar Is. (Nov., 1933) showing the hole made by a species of *Lithophaga*. The winding grooves surrounding the hole are presumably the impressions of worm-tubes. (×3).

FIG. 17.—Calcareous mass from the apex of the visceral coil of *T. niloticus* from Sister Is., Andamans (24.ii.33). (×5).



H S Rao & S Mondul Photo

SEASONAL VARIATIONS IN THE DISTRIBUTION OF *SAGITTA* OF THE MADRAS COAST.

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INTRODUCTION.

A preliminary account of the Plankton of the Madras coast was published five years ago (K. S. Menon, 1931) in which was recorded for the first time the occurrence of *Sagitta* along this coast. Menon observes that *S. bipunctata* occurs in the plankton collections fairly regularly and uniformly during all seasons. In a review of this paper published in '*Nature*' (1932) the conclusion was drawn that this uniform distribution is probably due to the tropical condition of the sea. As I have discussed in a later part of this paper, wherever the distribution of *Sagitta* was studied it has been definitely shown that seasonal variations of most of the species is a marked feature of its occurrence, hence the statement of Menon about the uniformity of its distribution was naturally noted with some interest.

Since the Plankton of the Madras coast had never been studied before Menon's work was of the nature of a pioneer attempt and as such was accompanied with all those unavoidable obstacles which necessarily beset works of that type. He identified *Sagitta* of the Madras coast as *S. bipunctata* and recognised only one species. It may now safely be affirmed that this species is not found in Indian waters. From the west coast of India Doncaster (1902) collected thirteen species of *Sagitta* including a number of new forms and from the Bombay coast Lele (1936) obtained three species including one which was recorded for the first time. The only reference to *Sagitta* in the Bay of Bengal is found in the reports of the "Siboga" Expedition (Fowler, 1906). Though that Expedition did not investigate the Bay of Bengal two of the distribution charts of the Reports of the Expedition make note of the occurrence of *S. enflata* and *S. subtilis*. From Menon's collections, which were carefully preserved in the Zoological Laboratory of the Madras University, the author identified five species (John, 1933) and two more species, *S. planktonis* and *S. hispida* have since been identified and included in this paper, but so far no specimen of *S. bipunctata* has been observed either in the Bay of Bengal or in the West coast. It was probably this mistake in identification which was responsible for the misconception that *Sagitta* occur fairly constantly during all the seasons: some species or other always occurs during most of the months, though not always showing the same degree of abundance.

A few years after the publication of Menon's paper the Madras University kindly awarded me a fellowship, which enabled me to carry on some investigations in the University Laboratory. During this time I made a thorough examination of the entire material collected by Menon and through the kindness of the Director of the laboratory was

able to collect some new material as well, but before long I had to leave Madras. The publication of my results was withheld with the hope that I may be able to carry out some more analysis with fresh material. However, since time and circumstances never permitted me to realize this object, I am now venturing to publish these results, which though fairly complete and conclusive are not entirely based on material collected under my personal supervision. The fact that I have used the very material which formed the basis of Menon's work has the added advantage of eliminating the possibility of all exceptions regarding dates and time of catch.

From the captures of Burfield and Harvey of the " Sealark " Expedition (1926) Aida for Japan (1897) Michael for Philippines (1919), Fowler for " Siboga " (1906), Doncaster for the Maldive and Laccadive Islands (1902) and Lele for Bombay (1936) it is evident that the Indo-Pacific region is very rich in Chaetognatha. So far some thirty valid species of *Sagitta* are recognised, out of these no less than twenty one are found in these collections. The great uniformity of *Sagitta* fauna over this vast region is also clearly brought out when these collections are compared. Eight species are found in common in five of the collections, extending from Japan to the Western Indian Ocean and no fewer than thirteen species are found from Philippines to the coast of Africa. Out of these *S. enflata*, *S. tricuspidata*, *S. serratodentata*, *S. hispida* and *S. regularis* have been recorded from the Arabian sea. The Maldive and Laccadive collections have also brought to light a number of new forms, e.g., *S. septata*, *S. polydon*, *S. pulchera*, *S. gardineri*, *S. ferox* and *S. robusta*, to this must be added *S. bombayensis*, sp. nov. and *S. bedoti*, recorded from Bombay. Taking all these into consideration it will be seen that the Arabian Sea has yielded fifteen species of *Sagitta*, out of which seven species are common in the rest of the Indian Ocean. From the Bay of Bengal only eight species have been so far recorded, of these four are found in the Arabian Sea and six species, i.e., *S. hispida*, *S. enflata*, *S. subtilis* *S. neglecta*, *S. tenuis* and *S. planktonis* are common to the rest of the Indian Ocean. Two of the new species of the Maldive and Laccadive regions have been obtained from Madras also, but *S. tenuis*, *S. neglecta*, *S. planktonis* and *S. subtilis* have not so far been observed in the Arabian Sea.

The plankton collections described in this paper were made under conditions quite different from those employed at other Marine Biological Laboratories. On days when a collection was to be made a local fisherman was engaged. Early in the morning before sunrise he sets out into the sea in the common fishing craft called ' catamaran ', which is made by yolking together three to five cylindrical logs of light wood into a shape remotely resembling a flat boat. The crudeness of its construction hardly enables it to gather a speed of more than three miles an hour even when under full sail. Collections were made with a simple tow net made of No. 6 standard silk bolting cloth (74 meshes to the inch). The fisherman was always given strict instructions to use more or less the same locality for towing and to drag the tow net always a definite number of times. By these instructions it was hoped to confine the collections to one definite area and to keep the duration of the drag constant as far as possible under such conditions.

Owing to the simple nature of the methods employed it may be argued that no definite and positive conclusions could be drawn from the analysis of such collections, but in spite of its simplicity, the collections have been fairly regular and systematic and give an accurate idea of the distribution of the plankton fauna during all the months of the year. Further as the collections extended over a period of four years they give great scope for comparison and confirmation of results.

Tables 1—4 represent an analytical study of the distribution of *Sagitta* from 1929-1932. It was probably in 1929 that the Madras University first decided to study the Plankton fauna of the Madras coast. During this year collections were not quite regular. I was not able to find any material of collections made in March, April, May and August. Even during the other months the collections were not rich in *Sagitta*. The collections for 1930 were the most regular and systematic and these yielded a complete set of results for the present study. In 1931 captures were made during January, March, April, May, June, July, August and September, and out of the collections of 1932 I was able to study only part of the materials collected during March, April, May, June and July.

In the present work I take the collections of 1930 as typical and those of 1929, 1931 and 1932 are included only for comparison. The 1930 collections of Madras has one great advantage over any other collections made elsewhere in that they yield a complete record of the distribution of *Sagitta* during all the months of the year.

As I have already pointed out seven species of *Sagitta* have so far been recorded from the Madras coast. In certain cases some specimens have been regarded as ' doubtful '. These do not represent unidentified species but are mostly specimens of one or other of the definite species which are partly damaged or mutilated.

During January *S. enflata* was most numerous though their number was not comparatively high. *S. gardineri*, *S. tenuis* and *S. neglecta* were also found; of these *S. neglecta* was only represented by a very few specimens. *S. planktonis*, *S. robusta* and *S. hispida* were not present during this month. In February *S. enflata* and *S. gardineri* became much scarcer, while *S. tenuis* becomes the most dominant species and *S. neglecta* still continues to be represented only by a few specimens. As in January *S. robusta*, *S. planktonis* and *S. hispida* are totally absent.

In March though *S. enflata* is still represented by a few specimens *S. gardineri* is totally absent and while *S. tenuis* maintains its predominance *S. neglecta* is scarcer than during the preceding month, being represented only by three specimens for the whole month. During this month *S. robusta* first begins to make its appearance and is represented by three specimens, while *S. planktonis* and *S. hispida* still continue to be conspicuous by their total absence.

April shows the same scarcity for *S. enflata* as in the preceding month but *S. gardineri* begins to reappear. *S. tenuis* which had been showing a progressive tendency towards increase in numbers, reaches its maximum intensity and is represented by a quantity which is not surpassed by any other species during any other month. *S. neglecta*

and *S. robusta* are still very scarce. In June *S. enflata* becomes comparatively more numerous and *S. gardineri* also increases in number, while *S. tenuis* shows a sudden fall. The most dominant species during this month is *S. neglecta*, which seems to have increased suddenly. *S. robusta* is also fairly well represented and *S. planktonis* begins to appear for the first time in the year.

S. tenuis is totally absent in July and from now onwards till the end of the year it is not found in the tow net water at all. During this month *S. enflata* is more numerous than *S. gardineri*. However the most conspicuous species of the month is *S. neglecta*. *S. robusta* also reaches its maximum, while *S. planktonis* is fairly well represented. *S. hispida*, which was totally absent from January to June, appears suddenly in the beginning of July and catches made during this month show its maximum for the whole year. *S. planktonis* also reaches its maximum. *S. enflata*, which has been steadily increasing in numbers from the middle of February, now reaches a state of abundance. After the 9th July though three collections were made there were no traces of even stray specimens of *Sagitta*. However they reappear again on the 10th August. The collection of this date gives the maximum for *S. enflata* and *S. gardineri*. *S. hispida* and *S. planktonis* are also fairly well represented, but three species *S. tenuis*, *S. neglecta* and *S. robusta* are totally absent and continued to be so till the end of the year.

The quantity of *Sagitta* in the plankton dwindles considerably by the beginning of September. In the collection of 12th September though *S. enflata* and *S gardineri* are dominant *S. planktonis* and *S. hispida* are only represented by stray specimens. During this month a second collection was made on the 19th, but *Sagitta* was totally absent, and in October though six collections were made not a single specimen of *Sagitta* could be found in them It may therefore be concluded that from the middle of September till the beginning of November *Sagitta* are not found in the surface plankton fauna of the Madras coast. In November though they reappear they are only represented by stray specimens and this continues on till the end of December.

Comparing the above analysis for 1930 with those of 1929, 1931 and 1932 we find a great deal of uniformity in the distribution of the various species during the different seasons, for example in 1929 the collections of February, July and August show very close similarity. During January and February *S. robusta*, *S. planktonis* and *S. hispida* are totally absent. In July *S. enflata* is numerous as in 1930 and in the same month *S. planktonis* and *S. hispida* reach their maximum. From June *S. tenuis* is totally absent and though ten collections were made from the 26th September to 28th October not a single specimen of *Sagitta* was observed, thus supporting the condition of October 1930.

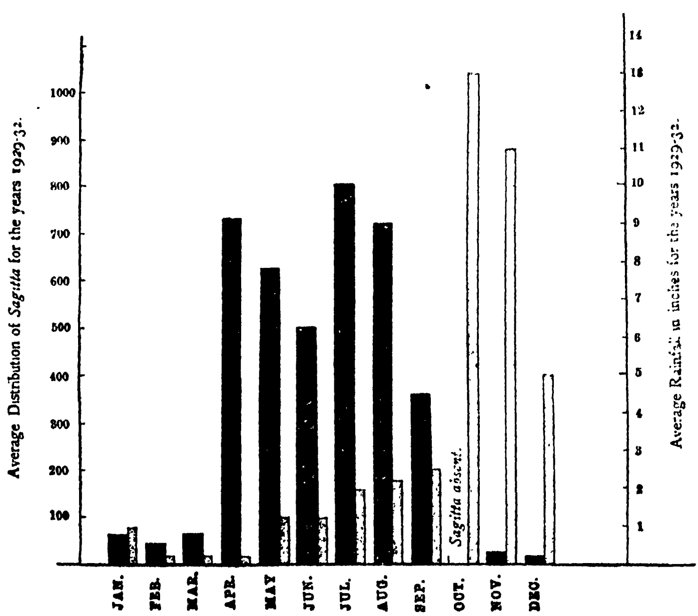
The April collections of 1931 are very similar to those of 1930. *S. tenuis* reaches its maximum but unlike 1930 *S. enflata* is totally absent. This does not, however, alter the general conclusions regarding the distribution of *S. enflata* since in April 1930 only a few stray specimens of that species were recorded, *i.e.*, one to eight specimens in each catch. *S. neglecta* and *S. planktonis* reach their maxima on 3rd June, while in 1930 *S. planktonis* shows its greatest intensity only on the 9th August.

Out of the 1932 collections I was not able to examine the entire lot. So I selected those collections which showed the largest number of *Sagitta* and only analysed them. Out of the March collections only one was examined. Comparing this with the one made on 14th March 1930, it was found that in both cases *S. tenuis* is the most predominant species, though the latter was much richer in numbers. In both cases a few specimens *S. enflata* and *S. neglecta* were also obtained. The April collections of 1932 compare very well with similar collections of 1930. In both cases *S. tenuis* reaches its maximum, while *S. enflata*, *S. gardineri*, *S. neglecta*, *S. robusta* and *S. planktonis* only show evidence of their occurrence by the presence of a few stray specimens only.

The collections of May 1932 are rich in *S. enflata*, *S. gardineri*, *S. tenuis* and *S. robusta*, while *S. planktonis* is represented by only a few specimens. With regard to most of the species mentioned above the numbers are much higher than those of 1930. However, in both cases it is evident that during this month *S. neglecta* reaches its maximum. This month is also interesting because it is during this time of the year that the maximum number of species is found.

In July *S. enflata* and *S. planktonis* reach their maximum and the collection of 25th July 1932, was the richest for all the four years for *S. enflata* and *S. hispida*.

Table No. 5 and the accompanying graph show the variations in the intensity of Distribution during the different months. This table



DISTRIBUTION OF SAGITTA IN RELATION TO RAINFALL.

Number of Sagitta.......

Rainfall in Inches.......

represents the aggregate average for each month taking the collections of all the four years into consideration. Thus for instance in January

1929 two collections were made in the same month. In 1930 though five collections are on record only three of them showed the occurrence of *Sagitta* and in 1931 only one collection has been recorded. In calculating the aggregate average all the dates in January for all the years are taken together excluding those dates, on which there were no traces of *Sagitta*.

From table 5 it will be seen that in October *Sagitta* are totally absent from the surface plankton. In 1929 this absence was first noticed towards the beginning of the last week of September, in 1930 from the 19th and in 1931 few specimens were found even on the 30th.

Before attempting to explain the causes for these conspicuous differences in the intensity of periodic distribution of *Sagitta* in the Indian waters it is necessary to consider certain general principles. It has been stated by Johnstone (1908) that the nature of plankton distribution will depend on the hydrographic and meteorological conditions or in other words on variations in wind, rain, light, barometric pressure, heat, etc. Along the coast these factors change rapidly and are governed by seasonal changes of the locality. It may also be said that the intensity of any type of plankton will depend also on the intensity of other planktonic organisms which constitute the food of the former and these in turn will depend for their abundance either on the physical conditions of the sea or on their life cycles. This is very well illustrated by the work of Herdman, Scott and Dakin (1910) on an intensive study of the Marine plankton around the south end of the Isle of Man. They have observed that certain planktonic organisms show a remarkable regularity in their time of appearance. For example the nauplii of *Balanus* began to appear on February 22nd in 1907, February 13th in 1908, and February 6th in 1909. This is one of the cases where the regular periodic occurrence depends on the sequence of events in life cycle, which constitutes the dominant factor in determining the composition of the plankton at a given place and time. The occurrence of fish eggs and larvae and the crab zoea is also due to such sequence in life cycles which fall at definite times.

In the case of *Sagitta* it has been definitely established that they do not have any particular breeding seasons. During all the months of the year and at all times the mature specimens carry ripe eggs. In the case of *Spadella cephaloptera* it has been shown that the eggs are shed at intervals of eight to ten days (John, 1933). In *Sagitta* the condition may be more or less the same, considering that the two are very closely allied, so that it may be safely asserted that increase during certain seasons does not depend on the breeding habits of the animal.

During my stay at Plymouth I reared considerable numbers of *Sagitta* and *Spadella* in the Laboratory of the Marine Biological Association and both types were found to thrive on Harpacticids ; these and similar small Crustaceans, which form the food of these animals are invariably found in the plankton during all the months, in the tropical waters. Therefore the postulate that the abundance of *Sagitta* during certain seasons may depend on the abundance of certain other planktonic organisms, which constitute their food, may be dismissed with equal certainty.

The only other factor therefore which remains is change in hydrographic conditions. Concerning this Kofoid (1903) says 'Somewhat regular alternations of growth and rest, of fission and spore formation or parthenogenesis and sexual reproduction are fundamentally the basis of cyclic movements in plankton production. The amplitude and to some extent the location and duration of the pulses are plainly affected by various factors of the environment—light, temperature, vegetation, tributary waters, various hydrographic factors, food supply and possibly also by chemical conditions, not directly concerned with nutrition but available data fail completely to afford any satisfactory environmental factor or groups of factors which stand in correlation with the cyclic movements in production.' However, when considering the cyclic movements of *Sagitta* we find that the periods of seasonal rains along the Madras coast seems to coincide with the periods of scarcity or absence of *Sagitta* in the surface plankton. During the greater part of the year the River Coovum, which reaches the coast close to the Northern side of the University is separated from the sea by a narrow bar of drift sand, but during the rainy season this bar is broken up and the rain water which accumulates in the river forces its way into the sea loaded with mud and dirt of the city. The direction of the coastal currents and the wind cause this muddy water to spread along the coast as a broad patch of reddish brown, clearly distinguishable from the sea water beyond. During this season tow netting is not usually conducted but during certain years when it was desired to obtain a complete record for all the months the fisherman was instructed to drag the net beyond this patch of muddy water. Even then *Sagitta* was not obtained. During the rainy season owing to the admixture of rain water there is bound to be a reduction in the percentage of salinity in the surface layers of the sea.

In 1931 I conducted some experiments with living specimens of *Sagitta* at Plymouth, to investigate their reactions to change of salinity and it was observed that even the slightest change makes them dormant. If the salinity is only altered in superficial layer they sink lower down. The hydrogen-ion concentration of the body fluids of marine animals bears a close relation to the hydrogen-ion concentration of the sea water. Since in the majority of species of *Sagitta* the body wall is thin and flabby any change in the hydrogen-ion concentration of the surface sea water will be felt by the animal which will consequently sink to the lower depths. It seems therefore very probable that the cause of the total absence or scarcity of *Sagitta* during the rainy months is the change of salinity brought about by the admixture of rain water in the superficial layer of the sea.

This conclusion seems to be very well supported by independent observations of Lele (1936) in the Bombay harbour. Of the three species described by him *S. gardineri* is the only one, in which the body wall is thin and flabby and from the table of surface distribution which he has given it will be seen that during March, April and May *S. gardineri* is totally absent from the Bombay coast. In June it is very scarce but from that time onwards there is a steady increase till September. In October the number again falls but rapidly rises again till it reaches

its maximum in December. It will be seen from his table that *S. gardineri* shows two maxima, one in September and the other in December. Alternating with these two periods of maxima are the rainy seasons of Bombay during which times they either become scarce or totally absent. The two other species recorded from Bombay also show seasonal variations in their intensity. For example *S. bedoti* shows three maxima during January, April and August. *S. bombayensis* shows four maxima during the year. It will be noticed that in the case of *S. bedoti* also the season of minimum distribution coincides with the rainy months as in the case of *S. gardineri*.

Species of Chaetognatha in which the body wall is tough and rigid such as *Spadella cephaloptera* are capable of withstanding considerable changes in salinity. *Spadella cephaloptera* is unaffected even when the salinity is reduced to 80 per cent of the normal (John, 1933). I have examined specimens of *S. bedoti* and I have also seen a few specimens of *S. bombayensis*, which Dr. Lele kindly showed me in 1934. In both these cases the body wall is rigid and though not very thick is capable of maintaining the shape of the body unlike *S. gardineri* or *S. enflata*. This characteristic probably enables these two species to withstand certain degree of chemical changes in the sea brought about by the addition of rain water and this probably explains why they do not become totally absent during the rainy seasons.

The south-west monsoon commences on the west coast of India somewhere about the middle of May and its vigour continues on till the end of June. During October Bombay again gets a fair share of rain from northerly winds.

On the East coast the south-west monsoon reaches very late and it passes northwards with only a few light showers along the Madras coast. Madras experiences its heaviest rainfall during the north-east monsoon. This wind, which collects some moisture during its progress across the Bay of Bengal, strikes the Madras coast towards the end of September and gives a considerable amount of rainfall during October, with moderate showers during November and December. Madras therefore has only one rainy season extending from October to December.

The distribution of *Sagitta* during the various months in relation to the average rainfall for each month is shown in the accompanying graph (*vide* text-fig. p. 87).

This graph shows that only in those months when the rainfall is very great the distribution of *Sagitta* is affected. For example at Madras though there are occasional showers in January, July, August and September these do not seem to have any effect on the itensity of distribution of *Sagitta* for it is only natural to infer that such showers cannot alter the salinity of the sea and further, the river Coovum does not empty itself into the sea during these months. But from October to December, when the rain fall is heavy and when there is a considerable rush of tributary waters the salinity is bound to change to such an extent as to make it unsuitable for these delicate organisms to survive in the surface waters.

Out of the three species recorded from Bombay I have only taken two of the well established species into consideration, since the third

is a new species, which appears to behave quite differently from other types. I shall not attempt to comment on this peculiarity till we know some more details regarding its habits and distribution.

Doncaster (1902) in his work on the Chaetognatha of the Maldive and Laccadive Islands does not go into statistical details regarding intensity of distribution. However, the following general idea may be gathered from a study of his paper :—

S. tricuspidata	Not found in April.
S. serratodentata	Common in winter and spring.
S. hispida	Scarce in winter but abundant in April.
S. regularis	Small numbers in winter.
S. robusta	Abundant in winter but scarce in April.
S. gardineri	Moderately abundant in winter.
S. pulchra	Moderate in winter and spring.
S. polydon	Fairly abundant in winter and spring.
S. septata	Moderately common in winter and spring.

From this it may be safely inferred that in the Maldive and Laccadive regions almost all the species reach their maxima during the colder months November to January, the only exception being *S. hispida* which seems to reach its maximum in Summer, just before the commencement of the rains. The rainy seasons in these regions are very much similar to those of Bombay, hence the distributions in these two places are more or less similar. In Bombay also *S. gardineri* reaches its highest maximum in December, while *S. bedoti* is scarce in winter but abundant in April, like *S. hispida* in the Maldive and Laccadive regions. It is therefore evident that on the Indian coast the seasonal fluctuations in the surface distribution of *Sagitta* is mainly governed by the seasons of local rainfall. As the rainy season varies from place to place the seasonal distribution of *Sagitta* is also bound to vary from place to place.

All the seven species recorded from Madras reach their maxima during the hot months April to August. For example *S. tenuis* reaches its maximum in April, *S. neglecta* in May, *S. robusta* in June, *S. enflata*, *S. planktonis* and *S. hispida* in July and *S. gardineri* in August. Of the seven species *S. enflata*, *S. gardineri* and *S. neglecta* occur during all the months of the year except October. The remaining four species *S. tenuis*, *S. robusta*, *S. planktonis* and *S. hispida* are only found during the summer months. We know very little about the vertical distribution of *Sagitta* in these waters and therefore it will be hazardous to venture upon any speculative suggestions before sufficient data are available. In the San Diego region of California where the periodic distribution of *Sagitta* has been recorded (Michael, 1911) the same condition is noticeable. For example *S. bipunctata* seems to be present during all the months, while *S. enflata*, *S. hexaptera*, *S. lyra*, *S. neglecta*, *S. planktonis* and *S. serratodentata* are found only during certain months. Michael makes no attempt to explain this phenomenon. Are they carried away by the surface current of the sea or do they sink to the lower depths during those months when they are not found in surface hauls. These questions can be answered only after a more intensive study of the vertical distribution of the various species during the different seasons of the year.

In conclusion I wish to express my deep sense of gratitude to the authorities of the Madras University and to Mr. R. Gopala Ayyar, Director of the University Zoological Department, for all the facilities they provided me for carrying on this work in their laboratory. My thanks are also due to Dr. Baini Prashad, Director of the Zoological Survey of India, for the loan of periodicals from the Zoological Survey Library.

SUMMARY AND CONCLUSIONS.

1. *Sagitta* does not show a uniform distribution throughout the year in the surface plankton. Out of the seven species recorded from Madras only two are found during most of the months. The other five appear only during the summer months.
2. Each species reaches its maximum only once in the year on the Madras coast and the periods of maxima are different for different species.
3. The distribution of *Sagitta* is at its minimum when the rain fall is very heavy, but it cannot be applied as a general rule that the distribution of *Sagitta* is inversely proportional to the rainfall, because slight occasional showers or irregular rains do not affect their intensity. From these observations the conclusion is drawn that *Sagitta* disappears from the surface plankton when the salinity of the sea water is appreciably altered by the admixture of rain and tributary waters.
4. The periods of maxima do not depend on the breeding habits or the abundance of any particular type of food of the animal.
5. The periods of maxima and scarcity vary from place to place always depending on the nature of the local rainfall. This is supported by recent work carried out at Bombay.

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TABLE NO. 1.

Surface Distribution of Sagitta *for the year 1929.*

Date.	*S. enflata.*	*S. gardineri.*	*S. tenuis.*	*S. neglecta.*	*S. robusta.*	*S. planktonis.*	*S. hispida.*	Doubtful forms.
10th Jan. 1929 . . .	12	29	..	3	..	..	..	..
27th Jan. 1929 . . .	57	28	1	2	..	..	..	..
11th Feb. 1929 . . .	2	4	11	2	..	..	..	..
19th Feb. 1929 . . .	7	2	27	4	..	..	..	..
12th June 1929 . . .	82	124	..	..	..	85	62	..
2nd July 1929 . . .	176	85	..	..	..	187	149	..
12th Sept. 1929 . .	82	124	..	..	..	85	62	..
16th Sept. 1929 . .	143	217	..	8	..	98	31	..
26th Sept. 1929 . .	..	..	..	..	..	..	..	..
28th Sept. 1929 . .	..	..	..	..	..	..	..	..
4th Oct. 1929 . . .	..	..	..	..	..	..	..	..
5th Oct. 1929 . . .	..	..	..	..	..	..	..	..
13th Oct. 1929 . . .	..	..	..	..	..	..	..	..
18th Oct. 1929 . . .	..	..	..	..	..	..	..	..
20th Oct. 1929 . . .	..	..	..	..	..	..	..	..
21st Oct. 1929 . . .	..	..	..	..	..	..	..	..
25th Oct. 1929 . . .	..	..	..	..	..	..	..	..
28th Oct. 1929 . . .	..	...	..	..	..	..	..	..
6th Nov. 1929 . . .	4	2	..	2	..	..	5	..
12th Nov. 1929 . . .	..	..	..	..	..	..	7	2
18th Nov. 1929 . . .	8	5	..	5	..	..	2	..
29th Nov. 1929 . . .	..	..	..	..	..	..	..	..
30th Nov. 1929 . . .	..	..	..	..	..	..	..	..
6th Dec. 1929 . . .	3	7	..	3	..	..	..	..
8th Dec. 1929 . . .	..	..	..	..	..	..	..	..
9th Dec. 1929 . . .	5	8	..	1	..	..	..	..
13th Dec. 1929 . . .	1	7	..	1	..	..	..	2
18th Dec. 1929 . . .	..	..	..	..	..	..	..	..
20th Dec. 1929 . . .	15	10	..	4	..	..	..	..

Table No. 2.

Surface Distribution of Sagitta *for the year 1930.*

Date.	*S. enflata.*	*S. gardineri.*	*S. tenuis.*	*S. neglecta.*	*S. robusta.*	*S. planktonis.*	*S. hispida.*	Doubtful forms.
13th Jan. 1930. . .	55	37	33	9	..	..	..	..
20th Jan. 1930. . .	60	19	14	4	..	..	..	..
21st Jan. 1930. . .	3	1	14	3	..	..	..	..
23rd Jan. 1930. . .	..	..	..	..	..	..	..	..
30th Jan. 1930. . .	..	..	..	..	..	..	..	..
5th Feb. 1930. . .	..	..	..	..	..	..	..	..
7th Feb. 1930. . .	..	6	12	4	..	..	..	13
10th Feb. 1930. . .	..	2	27	3	..	..	..	..
15th Feb. 1930. . .	4	5	131	5	..	..	..	..
19th Feb. 1930. . .	6	3	14	..	..	..	..	..
26th Feb. 1930. . .	..	..	..	..	..	..	..	..
3rd Mar. 1930. . .	2	..	23	1	1	..	..	..
8th Mar. 1930. . .	3	..	126	1	..	..	..	..
14th Mar. 1930. . .	2	..	119	1	2	..	..	..
22nd Mar. 1930 . .	1	..	8	..	..	..	..	5
29th Mar. 1930. . .	..	..	..	..	..	..	..	..
1st April 1930 . .	..	..	..	..	..	..	..	..
2nd April 1930 . .	1	..	30	1	1	..	..	..
16th April 1930 . .	..	..	875	..	..	..	..	..
18th April 1930 . .	5	..	1986	..	3	1	..	..
23rd April 1930 . .	8	16	148	2	..	..	..	..
29th April 1930 . .	..	..	..	..	..	..	..	..
1st May 1930. . .	..	..	..	..	..	..	..	..
5th May 1930. . .	..	..	..	..	..	..	..	..
15th May 1930. . .	161	62	124	187	40	5	..	..
29th May 1930. . .	42	29	5	..	..	..	..	..
4th June 1930. . .	7	3	..	2	1	3	..	..
12th June 1930. . .	129	51	..	344	72	38	..	..
14th June 1930. . .	114	7	..	103	55	49	..	..
16th June 1930. . .	..	..	..	..	..	..	..	..
9th July 1930. . .	347	143	..	..	..	154	231	..
21st July 1930. . .	..	..	..	..	..	..	..	..
23rd July 1930. . .	..	..	..	..	..	..	..	..
25th July 1930. . .	..	..	..	..	..	..	..	..
6th Aug. 1930. . .	..	..	..	..	..	..	..	..
10th Aug. 1930. . .	387	562	..	..	..	59	165	..
11th Aug. 1930. . .	316	418	..	..	..	67	114	..
15th Aug. 1930. . .	118	135	..	..	..	27	17	..
20th Aug. 1930. . .	..	..	..	..	..	..	..	..
12th Sept. 1930 . .	184	237	..	..	..	..	..	..
19th Sept. 1930 . .	..	..	..	..	..	..	..	..
4th Oct. 1930. . .	..	..	..	..	..	..	..	..
5th Oct. 1930. . .	..	..	..	..	..	..	..	..
13th Oct. 1930. . .	..	..	..	..	..	..	..	..
18th Oct. 1930. . .	..	..	..	..	..	..	..	..
20th Oct. 1930. . .	..	..	..	..	..	..	..	..
25th Oct. 1930. . .	..	..	..	..	..	..	..	..
4th Nov. 1930. . .	18	13	..	3	..	..	..	..
5th Nov. 1930. . .	35	28	..	..	..	..	..	..
13th Nov. 1930. . .	14	12	..	..	..	..	..	..
2nd Dec. 1930. . .	15	12	..	..	..	..	..	..
9th Dec. 1930. . .	12	14	..	..	..	..	..	..

TABLES NO. 3 & 4.

Surface Distribution of Sagitta *for the years 1931 & 1932.*

Date.	*S. enflata.*	*S. gardineri.*	*S. tenuis.*	*S. neglecta.*	*S. robusta.*	*S. planktonis.*	*S. hispida.*	Doubtful forms.
21st Jan. 1931	4	7	2	4	..	..	..	5
5th Mar. 1931	12	..	87	3	7	..	..	..
20th Mar. 1931	..	..	21	..	..	..	..	..
3rd April 1931	..	17	1248	1	..	3	..	..
6th April 1931	..	4	457	3	..	2	..	..
8th April 1931	..	..	..	..	..	..	..	..
9th April 1931	..	15	168	1	..	..	..	1
10th April 1931	..	6	47	..	..	..	..	..
13th April 1931	..	..	..	..	..	..	..	..
15th April 1931	..	..	..	..	..	..	..	..
12th May 1931	83	21	14	293	26	2	..	17
21st May 1931	..	..	..	..	..	..	..	..
22nd May 1931	94	53	31	326	7	..	..	..
10th June 1931	14	38	..	91	4	3	13	..
12th June 1931	156	72	..	183	51	23	97	..
30th June 1931	169	287	..	376	69	485	180	..
1st July 1931	294	34	..	..	..	246	314	..
6th July 1931	173	183	..	21	13	..	..	..
7th Aug. 1931	263	477	..	4	1	89	63	..
9th Aug. 1931	114	211	..	1	..	1	4	..
13th Sept. 1931	..	..	..	..	..	..	..	..
30th Sept. 1931	24	4	..	..	..	..	..	..
16th Mar. 1932	1	..	56	1	1	..	..	..
18th April 1932	27	8	1642	22	1	..	6	..
27th April 1932	10	5	573	7	1	..	2	..
8th May 1932	48	52	186	252	12	2	..	..
17th May 1932	231	78	259	345	64	6	..	..
15th June 1932	147	96	..	176	19	47	..	..
25th July 1932	499	254	..	..	..	186	321	..

TABLE No. 5.

Average monthly distribution of Sagitta *for the years 1929-1932.*

Name of Species.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
S. enflata . .	32	3	3	5	109	98	300	240	134	×	16	7
S. gardineri . .	20	4	×	7	48	71	140	361	146	×	12	10
S. tenuis . .	11	37	63	717	108	×	×	×	×	×	×	×
S. neglecta . .	4	3	1	4	234	181	4	1	2	×	2	2
S. robusta . .	×	×	2	1	25	34	2	1	×	×	×	×
S. planktonis . .	×	×	×	×	2	81	155	49	49	×	×	×
S. hispida . .	×	×	×	1	×	36	203	73	25	×	×	×

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TROIS CYCLOPIDES (CRUSTACÉS COPÉPODES) NOUVEAUX DE L'INDE.

K. LINDBERG.

(Planches II et III.)

Dans son traité complet sur les cyclopides paru en 1929 F. Kiefer donne une liste de 20 espèces du groupe *Varicans-Bicolor* rangées dans le sous-genre *Microcyclops* de Claus et caractérisées principalement par la cinquième patte n'étant formée que d'un seul article pourvu d'une soie ; une forte soie attachée au bord latéral du cinquième segment thoracique représentant celle de l' article basal disparu. A cette liste il faut joindre 8 espèces décrites pendant ces dernières années. De ce total de 28 il n'y a guère que 2 qui, autant qu' il soit connu à présent, sont des espèces cosmopolites, les autres ayant presque toutes été rapportées de régions tropicales et sous-tropicales et plus de la moitié, c'est-a-dire 15, de l'Afrique seule. En vue de ces chiffres il est assez surprenant que de ce groupe, qui semble particulièrement bien représenté dans les pays chauds, on n'en connait encore que 3 espèces de la Péninsule Indienne, et, comme l'a fait déjà remarquer Kiefer, en ce qui concerne le *C.* (*M.*) *bicolor* et le *C.* (*M.*) *varicans*, rapportés par Sewell et par Gurney il n'est pas tout à fait certain qu' il s'est réellement agi des espèces typiques.

Au cours de récoltes récentes j'ai trouvé 2 espèces et une variété nouvelles appartenant à ce groupe, dont je donne ici la description.

Cyclops (Microcyclops) diminutus, sp. nov.

Description —Très petite espèce, de forme trapue.

Longueur des deux femelles portant des ovisacs de 550 µ et de 570 µ ; largeur maxima de 190 µ et de 210 µ. Rapport entre la longueur du céphalothorax et celle de la queue (abdomen + furca sans soies apicales) de 1 à 2·2 et de 1 à 2·3. Rapport entre la longueur du céphalothorax et sa largeur de 1 à 1·82 et de 1 à 2. Longueur du premier segment céphalothoracique légèrement supérieure à sa largeur. Parties látérales du bord postérieur des deuxième, troisième et quatrième segments thoraciques légèrement prolongées en pointe, de sorte que ces segments sont bien délimités les uns des autres ; par contre, la limite est peu distincte entre le premier et le deuxième segments céphalothoraciques. Le cinquième segment thoracique porte une longue soie sur son bord latéral et celui-ci est prolongé et un peu élargi distalement. Premier segment abdominal un peu moins long que sa largeur proximale ; il présente dans sa partie proximale une forme arrondie et globuleuse dans le sens antéro-postérieur ; il se rétrécit graduellement dans sa partie distale. Longueur du segment génital inférieure à celle des trois segments abdominaux suivants réunis. Les deuxième et troisième segments abdominaux sont de longueur à peu près égale ;

le quatriéme segment est considérablement moins long. Le bord distal du quatrième segment abdominal porte sur sa face ventrale une rangée continue de fines épines. L'opercule anal est de dimensions normales. Branches de la furca très légèrement divergentes. Leur longueur est de très peu inférieure à celle des troisième et quatrième segments abdominaux réunis; chez l'un des animaux elles étaient de 2·7 fois aussi longues que larges, chez l'autre de 3·1 fois aussi longues que larges. La soie latérale externe divise la branche de la furca dans la proportion d'environ 47 à 15. La longueur des soies apicales était chez les deux spécimens (du dedans en dehors) 62 : (?) : 150 : 30μ et 67 : (?) : 153 : 25μ. La soie apicale externe est forte et courte, la soie apicale interne est plus de deux fois aussi longue que la soie apicale externe; elle est très mince; les deux soies apicales médianes sont bien développées; la soie apicale médiane interne se trouvait cassée chez les deux animaux á une certaine distance de son extrémite; son épaisseur montrait cependant qu'elle devait être considérablement plus longue que la soie apicale médiane externe. Première antenne à 10 articles; rabattue elle dépasse légèrement le milieu du premier segment céphalothoracique; le deuxième article est le plus court et le premier le plus long. Branches des pattes natatoires à 2 articles; l'article terminal des exopodites est muni de 5 soies; la formule des épines est de 3. 4. 4. 3. Article terminal de l'endopodite de la quatrième paire de pattes environ 3 fois aussi long que large; il porte 3 soies sur son rebord interne et 2 épines apicales dont l'interne, déviée en dedans, est considérablement plus longue et plus forte que l'épine externe, leur longueur respective se trouvant chez les deux animaux dans le rapport de 1 à 0·6. L'épine apicale interne est moins que la moitié de la longueur de l'article qui la porte. Bord libre de la lamelle réunissant la base de la quatrième paire de pattes presque droit sans élevures latérales; celui de la troisième paire est muni d' un petit tubercule de chaque côté. La cinquième patte n'est formée que d' une soie assez courte munie de très petits poils. Le réceptacle séminal ressemble à celui du *C. bicolor*, mais les bras latéraux de la partie distale sont plus longs que ceux de la partie proximale. Les ovisacs sont accolés contre l'abdomen et ne dépassent pas l'extrémité de la furca.

Oeufs relativement grands mais peu nombreux, de 4 à 6 dans chaque sac. La couleur n'a pas été observée, les animaux n'ayant été examinés qu'après la mort. Mâle inconnu. (Figs. 1, 2, 3, 4, 5).

Habitat.—Un étang, à végétation aquatique très abondante, à Cansaulim (Goa) Inde Portugaise. Récolté au mois de novembre.

Remarques.—Par suite de la structure de la cinquième patte, se réduisant à une seule soie, il s'agit d'un membre du sousgenre *Microcyclops* de Claus du genre *Cyclops*, Müller. Il se rapproche le plus du *C.* (*M.*) *attenuatus* Sars, mais s'en différencie par les branches de la furca étant considérablement plus courtes et inférieures en longueur à celle des troisième et quatrième segments abdominaux réunis. Il s'en distingue aussi par la configuration différente du segment génital dont la largeur proximale est notablement plus grande que la largeur distale et enfin par le rapport différent entre la longueur des épines apicales de l'enp. 4.

Cyclops (Microcyclops) tricolor, sp. nov.

Description.—Petite espèce de forme trapue ; longueur de la femelle adulte de 665 μ à 715 μ ; largeur dépassant un peu le tiers de la longueur totale du corps ; céphalothorax formant environ les deux tiers de la longueur du corps, et la queue (abdomen + furca sans soies apicales) un tiers. Céphalothorax de forme ovoïde à l'état vivant ; chez les animaux tués à la formaline il devient un peu plus allongé ; il est à peu près 2 fois aussi long que large (chez 3 femelles adultes ce rapport était de 1.84 : 1, 2 : 1, 2 : 1). Premier segment céphalothoracique considérablement plus long que large. Limites entre les bords latéraux des segments céphalothoraciques beaucoup moins prononcées que chez l'espèce précédante. Cinquième segment thoracique portant de chaque côté une longue soie munie de poils ; bord latéral ne présentant qu'une faible ébauche de prolongement distal. Largeur proximale du segment génital surpassant la longueur du segment ; il se rétrécit graduellement du coté distal. Proximalement, l'épaisseur du segment génital dans le sens antéro-postérieur, de même que celle du céphalothorax, est considérable, donnant un aspect fortement globuleux à ces parties du corps. Longueur du segment génital légèrement inférieure à celle des 3 segments abdominaux suivants réunis. Les deuxième et troisième segments abdominaux sont de longueur à peu près égale entre eux ; le quatrième est de longueur moindre. Rebord distal du quatrième segment abdominal portant sur sa face ventrale une rangée de petites épines. Opercule anal de dimensions normales. Branches de la furca nettement divergentes. Elles surpassent en longueur celle des troisième et quatrième segments abdominaux réunis. Elles sont environ 3 fois aussi longues que larges. La soie latérale externe divise la branche de la furca dans la proportion d'environ 64 à 18. La soie apicale externe est forte et assez courte ; la soie apicale interne est un peu plus de deux fois aussi longue et très mince ; les deux soies apicales médianes sont bien dévéloppées. La longueur des soies apicales était chez deux spécimens (du dedans au dehors) : 92, 225, 175, 43 μ et 87, 218, 173, 42 μ. Première antenne à 11 articles ; rabattue elle dépasse le milieu du premier segment céphalothoracique ; le cinquième est l'article le plus court et le premier le plus long. Branches des pattes natatoires biarticulées. La formule des épines est de 3. 4. 4. 3 ; le nombre des soies de l'article terminal des exopodites est de 5. Article terminal de l' endopodite de la quatrième paire de pattes environ 3 fois aussi long que large ; épine apicale interne longue et forte, toujours plus de 3 fois aussi longue que l'épine apicale externe, elle atteint parfois 4 fois la longueur de celle-ci. Les deux soies proximales du rebord interne de l'article terminal sont assez courtes ; la longueur de l'épine apicale interne surpasse la moitié de la longueur de l'article. Le bord libre de la lamelle réunissant la quatrième paire des pattes est presque droit ; il présente des élevures latérales au niveau des autres paires. Cinquième patte formée seulement d' une soie munie de petits poils. Réceptacle séminal ressemblant dans les grandes lignes à celui de l'espèce précédante. Ovisacs accolés contre l'abdomen, n'atteignant pas l'extrémité de la furca ; ils contiennent chacun de 6 à 10 oeufs, assez gros. Couleur bigarrée jaune—orange dans les parties centrales du

céphalothorax, noirâtre et rose—saumon ailleurs; oeufs très foncés, vert—noir. Mâle inconnu (Figs. 6, 7, 8, 9, 10).

Habitat.—Récolté au mois de novembre en très petit nombre, dans une carrière abandonnée, remplie d'eau, à surface couverte de *Lemna* à Pandharpour (Deccan), en compagnie de *M. leuckarti* et de *M. rylovi vermifer.*

Remarques.—La seule espèce dont se rapproche le *C.* (*M.*) *tricolor* est le *C.* (*M.*) *linjanticus,* Kiefer, récolté dans l'Afrique du Sud. Il s'en distingue par les caractères indiqués au tableau comparatif ci-dessous.

C. LINJANTICUS.	*C. TRICOLOR.*
Branches de la furca 3·5 fois aussi longues que larges.	Branches de la furca plus courtes ; environ 3 fois aussi longues que larges.
Soie apicale médiane interne 4 fois aussi longue qu'une branche de la furca.	Soie apicale médiane interne n'atteint pas 4 fois la longueur d'une branche de la furca.
Ressemble beaucoup dans sa configuration à *C. bicolor.*	Se distingue nettement du *C. bicolor* tant par la configuration du cinquième segment thoracique que par celle de la furca et de ses appendices.

Cyclops (Microcyclops) varicans, pachyspina, subsp. nov.

Description.—Espèce relativement grande et robuste. Longueur de la femelle adulte de 700 μ à 760 μ ; largeur de 280 μ à 285 μ. Rapport entre la longueur du céphalothorax et celle de la queue de 1·76 : 1 à 2·2 : 1. Rapport entre la longueur et la largeur du céphalothorax de 1·60 : 1 à 1·73 : 1. Longueur du premier segment céphalothoracique inférieure ou égale à sa largeur ; il dépasse en longueur celle des 4 segments suivants réunis. Cinquième segment thoracique portant sur le rebord latéral une longue soie courbée. Premier segment abdominal moins long que large proximalement ; il se rétrécit graduellement dans sa partie distale ; sa longueur est inférieure à celle des 3 segments abdominaux suivants réunis. Branches de la furca parallèles ou très légèrement divergentes ; elles surpassent un peu la longueur des troisième et quartrième segments abdominaux réunis. Le rapport entre leur longueur et leur largeur est de 3·2 : 1 à 3·6 : 1. La soie apicale externe est forte et relativement longue ; la soie apicale interne est très mince et considérablement moins que 2 fois la longueur de la soie apicale externe. La longueur des soies apicales était chez trois femelles adultes (du dedans au dehors) : 63, 342, 217, 37 μ ; 67, 342, 234, 47 μ ; 77, 334, 234, 47 μ. Pennation des soies médianes hétéronyme (de même que chez les deux espèces précédantes). Première antenne à 12 articles ; les troisième et sixième sont les plus courts, et les premier, huitième et neuvième les plus longs. Rabattue, la première antenne atteint le rebord postérieur du premier segment céphalothoracique. Branches des pattes natatoires bi-articulées ; formule des épines de 3, 4, 4, 3. Article terminal de l'endopodite de la quatrième paire des pattes plus de 3 fois et près de 3 fois et demi aussi long que large ; ce rapport étant le plus souvent de 3·4 : 1. Epine apicale interne très fortement élargie dans sa partie proximale ; elle est notablement plus courte que l'article

qui la porte ; ce rapport étant de 1 : 1.52 à 1 : 1·62. Epine apicale externe beaucoup moins bien dévéloppée. Le rapport entre la longueur de l'épine apicale interne et celle de l'épine apicale externe est environ de 1·6 : 1 à 1·7 : 1. Cinquième patte formée seulement d'une soie pennée attachée à un article basal bien dévéloppé. Je n'ai pas observé d'épine sur le rebord interne de l'article. Réceptacle séminal ressemblant dans les grandes lignes à celui du *C.* (*M.*) *varicans.* Ovisacs dirigés au dehors et pouvant dépasser l'extrémité de la furca ; ils contiennent chacun de 15 à 18 oeufs de grosseur moyenne. La couleur n'a pas été observée à l'état vivant. Mâle inconnu. (Figures 11, 12, 13, 14, 15).

Habitat.—L'étang à Cansaulim (Goa) dans lequel fut trouvé le *C.* (*M.*) *diminutus* déjà décrit. Seulement quatre femelles adultes furent récoltées dans le mois de novembre.

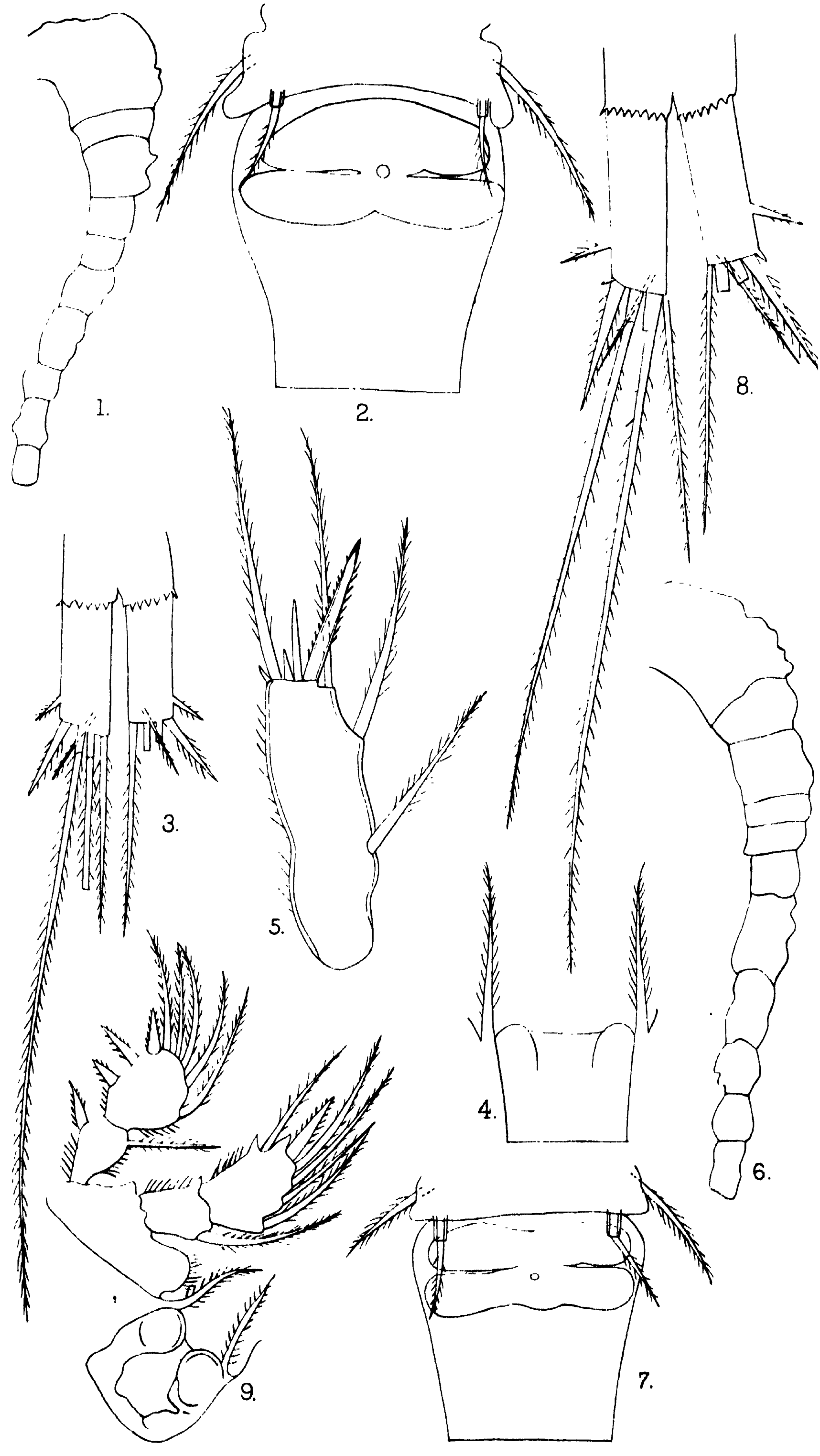
Remarques.—Le microcyclope qui vient d'etre décrit se rapproche beaucoup du *C.* (*M.*) *varicans* mais s'en distingue notamment par la configuration de l'article terminal de l'enp. 4 qui est plus allongé, et par la structure très particulière de l'épine apicale interne de cet article, cette épine étant très fortement épaissie dans sa partie proximale.

Planche II.

1. *C.* (*M.*) *diminutus* . . . ♀ Première antenne.
2. *C.* (*M.*) *diminutus* . . . ♀ Segment génital.
3. *C.* (*M.*) *diminutus* . . . ♀ Furca.
4. *C.* (*M.*) *diminutus* . . . ♀ Lamelle réunissant base de la troisième paire des pattes.
5. *C.* (*M.*) *diminutus* . . . ♀ Article terminal de l'enp. 4.
6. *C.* (*M.*) *tricolor* . . . ♀ Première antenne.
7. *C.* (*M.*) *tricolor* . . . ♀ Segment génital.
8. *C.* (*M.*) *tricolor* . . . ♀ Furca.
9. *C.* (*M.*) *tricolor* . . . ♀ Première paire des pattes.

Planche III.

10. *C.* (*M.*) *tricolor* . . . ♀ Article terminal de l'enp. 4.
11. *C.* (*M.*) *varicans* var. *pachyspina* . . . ♀ Première antenne.
12. *C.* (*M.*) *varicans* var. *pachyspina* . . . ♀ Segment génital.
13. *C.* (*M.*) *varicans* var. *pachyspina* . . . ♀ Furca.
14. *C.* (*M.*) *varicans* var. *pachyspina* . . . ♀ Article terminal de l'enp. 4.
15. *C.* (*M.*) *varicans* var. *pachyspina* . . . ♀ Cinquième patte.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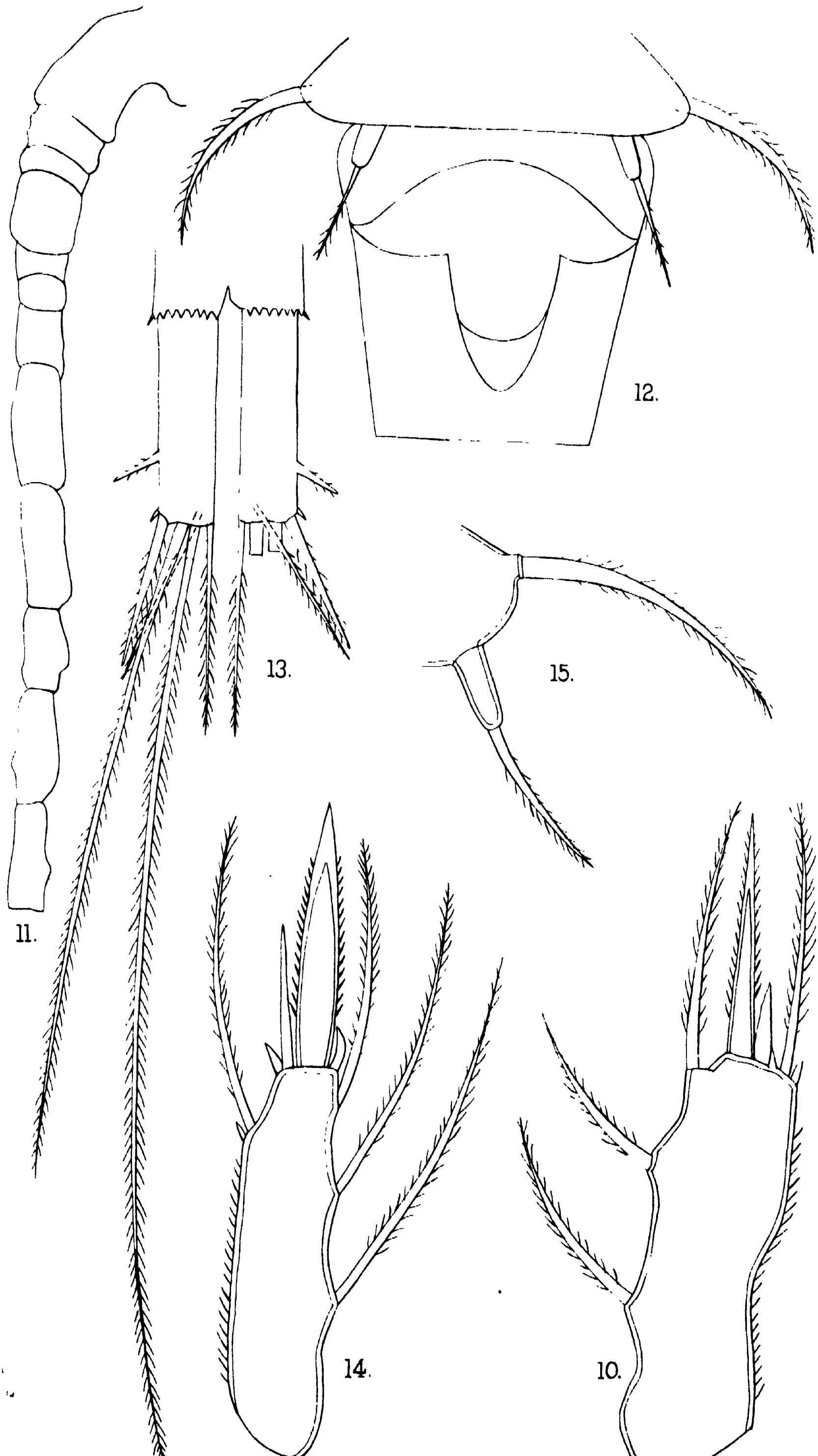
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ON A COLLECTION OF INDIAN EARTHWORMS OF THE FAMILY LUMBRICIDAE.

By DR. L. ČERNOSVITOV, *Zoological Institute, Charles University, Prague.*

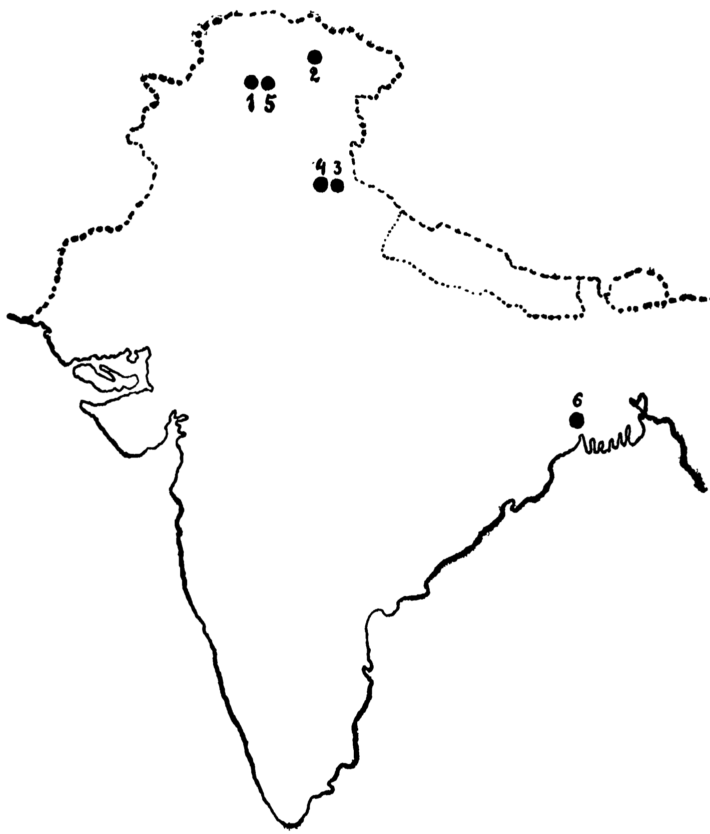
Terrestrial forms constitute the bulk of Indian Oligochaete fauna. All the Indian families, with the exception of the family Lumbricidae, belong to tropical families, which show a connection of the Indian fauna with Australia and New Zealand (all Megascolecidae), Malay Archipelago (the genera *Pheretima* and *Desmogaster*), Madagascar (the genus *Howascolex*), Africa (the genera *Gordiodrilus* and *Dichogaster*) and Central America (the family Diplocardiidae). The territory of the endemic species of the family Lumbricidae includes Middle and Central Europe, North Africa and a part of North America (the eastern part of the United States). In Asia endemic species are known from Palestine, Syria, Turkey, Persia, Caucasus, Turkestan, Tian-Shan, Tibet, Japan and India.

The northern limit of the territory of endemic species of Lumbricidae in North America and Europe coincides with the limit of glaciation during the Ice Age, and their present-day distribution may be explained by the influence of the ice cap which covered the northern part of Europe and North America (Michaelsen 1903, Černosvitov 1932 ; 1935*a*). The exact limits of the Lumbricid territory in Asia are not well known and the study of any fresh material, therefore, is not without interest. A few endemic species of Lumbricidae are known from Tian-Shan, Tibet and Japan. The Indian fauna includes only 4 such species—*Bimastus indicus* (Mich.), *Eophila mariensis* (Steph.), *Dendrobaena kempi* (Steph.) and *Allolobophora prashadi* (Steph.). They are all concentrated in the Himalayas and the range of only one—*Bimastus indicus* (Mich.)—extends as far as Calcutta. This species is considered by Stephensen (1923, 1930) as the southernmost outpost of Lumbricidae, having spread in a southerly direction from the north—the Himalayas proper representing the line of separation between the Palaearctic and Oriental faunas of Earthworms.

In the following pages I deal with a collection of Lumbricidae belonging to the Indian Museum. My thanks are due to Dr. B. Prashad, Director of the Zoological Survey of India, for the opportunity of examining it.

Amongst the 11 species identified there are two peregrine species which are recorded for the first time from India ; these are *Eiseniella tetraedra* (Sav.) f. *typica* and *Octolasium cyaneum* (Sav.). Two other—*Allolobophora jassyensis* (Mich.) and *Eophila himalayana*, sp. nov.—are apparently Palaearctic forms, though the latter may be endemic in India ; both the species, however, are found in Western Himalayas (Punjab)

and this supports the general conclusions of Stephenson on the distribution of Indian Lumbricidae (*vide* map, text-fig. 1).



TEXT-FIG. 1.—Map showing the distribution of endemic Indian Lumbricidae: 1. *Allolobophora jassyensis*, 2. *Allolobophora prashadi*, 3. *Dendrobaena kempi*, 4. *Eophila himalayana*, 5. *Eophila mariensis*, and 6. *Bimastus indicus*.

In the following list of the Indian Lumbricidae species marked with an asterisk are truly endemic species, while the others are the so-called peregrine species which are widely distributed almost all over the world, and are, therefore, of no importance in zoogeographic discussions.

List of Indian Lumbricidae.

Eiseniella tetraedra (Sav.) forma *typica*.
Eisenia foetida (Sav.).
Eisenia rosea (Sav.).
Dendrobaena rubida (Sav.).
Dendrobaena subrubicunda (Eisen).
* *Dendrobaena kempi* (Steph.).
Allolobophora caliginosa (Sav.) forma *typica*.
Allolobophora caliginosa (Sav.) forma *trapezoides* (A. Dug.).
**Allolobophora prashadi* (Steph.).

* *Allolobophora jassyensis* (Mich.).
* *Eophila mariensis* (Steph.).
* *Eophila himalayana*, sp. nov.
Bimastus tenuis (Eisen).
Bimastus eiseni (Lev.).
Bimastus parvus (Eisen).
**Bimastus indicus* (Mich.).
Octolasium lacteum (Örley).
Octolasium cyaneum (Sav.).
Lumbricus rubellus Hoffm.

Eiseniella tetraedra (Sav.) forma **typica.**

Kumaon Hills, Dhobi Ghat, 2 miles east of P. W. D. Bungalow. Dr. H. S. Pruthi coll., 2 specimens.
Kumaon Hills, The Lake, Naini Tal; alt. 6,359 ft. Dr. H. S. Pruthi coll., 2 specimens.

This species has not been recorded from India but is widely distributed all over. One of the specimens examined had a regenerated anterior part of the body: the male pores were situated on segment xii and the clitellum on segments xxi-xxvi.

Eisenia foetida (Sav.).

Kodaikanal, Palni Hills, S. India. Dr. S. L. Hora coll., 19+11+37 specimens.
Kodaikanal, Palni Hills, S. India from dung heap. Dr. S. L. Hora coll., 31+33 specimens.
Kodaikanal, Palni Hills, S. India along edge of a stream near Golf Link on way to Pillar Rocks. Dr. S. L. Hora coll., 41 mostly mature specimens.
Fern Hills, Nilgiris, S. India. Dr. S. L. Hora coll., 21 specimens.
Simla, W. Himalayas; alt. 6,000-7,000 ft. Dr. B. Chopra coll., 7+3 specimens.
Dharmsala, Punjab—from a heap of cow-dung. Dr. S. L. Hora coll., 4 specimens.

Eisenia rosea (Sav.).

Cart Road, Murree, W. Himalayas, Punjab. Dr. H. S. Pruthi coll., 5 specimens.
Dhar, Murree Sub-Divn., W. Himalayas, Punjab. Dr. H. S. Pruthi coll., 1 specimen.
Simla, W. Himalayas. 1 specimen.
Kodaikanal, Palni Hills, S. India—on the way to Pillar Rocks. Dr. S. L. Hora coll., 1 not fully mature specimen.
Rambhur River bank at Rambhur, Rambhur Valley, Chitral. Dr. B. Chopra coll., 1 specimen not fully mature.

Dendrobaena subrubicunda (Eisen).

Simla, W. Himalayas; alt. 6,000—7,000 ft. Dr. B. Chopra coll., 2 specimens.

The two specimens examined differ in some respects from the European individuals, chiefly in the arrangement of the setae. This species has been recorded from India and is widely distributed in other parts of the world (Europe, Siberia, North and South America), and I am, therefore, not inclined to regard the two aberrant specimens from India as representing a new variety. I include a brief description of these specimens for future reference.

Length 82 and 76 mm. Segments 114. Prostomium epilobous ($\frac{1}{2}$) or almost tanylobous. Anterior part of the body compressed dorso-ventrally, posterior end rounded. Skin pigmented strongly only on dorsal surface, posterior end very slightly pigmented. Setae widely paired, *ab*=*cd*, *aa*=2*ab*, *bc*=1$\frac{1}{2}$ *ab* (in European specimens *bc*=2*cd*, *cd*=*ab*, *aa*=1$\frac{2}{3}$ *ab*.) Ventral surface of segment xvi is glandular and the setae *ab* are situated on prominent papillae. Clitellum on segments xxvi-xxxi. Tubercula of puberty on segments xxviii-xxx.

Allolobophora caliginosa (Sav.) forma **trapezoides** (A. Dug.).

Fern Hills, Nilgiris, S. India. Dr. S. L. Hora coll., 1 specimen.
Bara Hotar, Murree Sub-Divn., W. Himalayas, Punjab—under stones. Dr. H. S. Pruthi coll., 1 specimen.
On hills sides at Jotla, Kangra Dist., Punjab—under stones. Dr. S. L. Hora coll., 1 specimen.
Kufri, Simla Hills, W. Himalayas; alt. 8,400 ft. Dr. B. Chopra coll., 15 specimens.
Simla, W. Himalayas: alt. 6,999—7,000 ft. Dr. B. Chopra coll., 4 specimens.
Asni River near Junga, Simla Hills, W. Himalayas; alt. 4,000 ft. Dr. B. Chopra coll., 1 specimen.
Simla, W. Himalayas. 3 specimens.
Kunusk, Chitral. Dr. B. Chopra coll., 17 specimens.
Rambhur River bank at Rambhur, Rambhur Valley, Chitral. Dr. B. Chopra coll., 1 specimen.
Under stones along banks of an irrigation channel off the Pallarga stream close to its junction with the Rambhur River, Rambhur Valley, Chitral. Dr. B. Chopra coll., 17 specimens.
A cultivated field near Uts or "Hot Springs", Lutkuh Valley, Chitral. Dr. B. Chopra coll., 21 specimens.
Under stones along banks of a small stream above Charun, Mastuj Valley, Chitral. Dr. B. Chopra coll., 1 specimen.
Ramram Gol below Arandu, Chitral. Dr. B. Chopra coll., 1 specimen.

In the large number of specimens from Chitral the spermathecae are obliterated in the muscle sheath. In dissections such specimens presented no spermathecae, but these were discovered in sections of the body wall. Such a case I described recently (1935*b*) in *Eophila cryptocystis* and Pool (1936) has shown that *Allolobophora dubiosa* (Örley) which was described as having no spermathecae really has these organs, but they are embedded in the muscles of the body wall. That permits us to doubt if in other species such as *Allolobophora acystis* (Mich.), *A. prashadi* (Steph.), *A. ribaucourti* Bretsch., *A. agatschiensis* Mich., and some others, the spermathecae are not so deeply embedded in the muscles that they cannot be seen in dissected specimens.

Allolobophora jassyensis (Mich.).

Topa, Murree Sub-Divn., W. Himalayas, Punjab; alt. 7,250 ft.—under stones. Dr. H. S. Pruthi coll., 2 specimens.

This species is widely distributed. We have no records about the occurrence of *A. jassyensis* from India, but it is known from Europe [Rumania (Jassy), Switzerland, South Russia (Mariupol Dist.)], Palestine, Egypt (Cairo), Turkestan (Tashkent), Caucasus (Baku, Lenkoran Dist.) and West Tian-Shan (Pokem River).

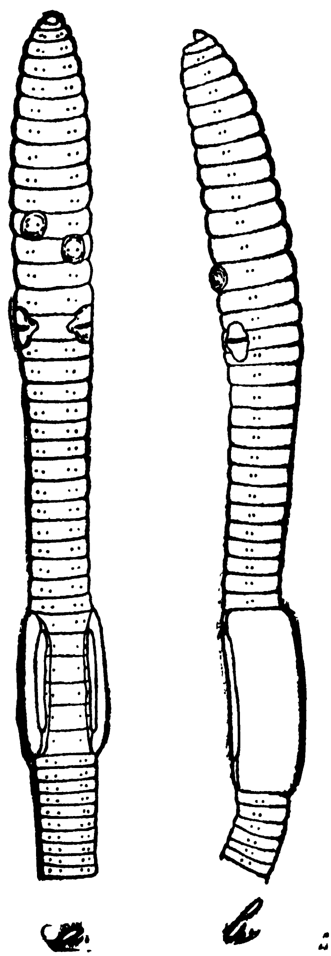
I had the opportunity of studying only two specimens from the Punjab. The largest of these is 76 mm. in length and 5 mm. thick and has 150 segments. Intersegmental furrows well marked. Setae

paired very closely, *ab*>cd, *ab* a little larger than *bc*, behind the clitellum $aa=1\frac{1}{2}$ *bc*. Prostomium epilobous ($\frac{1}{3}$). The setae *ab* on the x, xi, xxvii and xxviii or only xxvii segments situated on glandular papillae. The dissepiments 7/8-9/10 strongly thickened, 6/7 and 10/11 only slightly. Clitellum in both specimens extends over segments xxvii-xxxvi, and the tubercula of puberty over segments xxxi-xxxiv. In the larger specimen only two pairs of seminal vesicles are developed, as was observed by Michaelsen (1910) in specimens from Turkestan.

Eophila himalayana, sp. nov.

Simla, W. Himalayas ; alt. 6,000—7,000 ft. Dr. B. Chopra coll., 2 specimens.

Length of mature specimens 52 and 63 mm. diameter of anterior end about 2·5 mm., posterior end about 2 mm. Body rounded through-



TEXT-FIG. 2.—*Eophila himalayana*, sp. nov.
a. ventral view, *b.* side view of the anterior part of a specimen.

out. Segments about 128, large with well marked intersegmental furrows. Colour of alcoholic specimens yellowish, only the clitellum

dorsally reddish; skin without pigment. Prostomium epillobous ($\frac{1}{2}$). No dorsal pores could be discovered before the clitellum. Setae small, closely paired. Anteriorly *ab* a little larger than *cd*, $aa=3ab$, $bc=2\frac{1}{2}\,ab$, posteriorly ventral and dorsal pairs are more widely paired than anteriorly, *ab* a little larger than *cd*, $aa=2ab$, $ab=bc>cd$, $dd=\frac{1}{2}u$.

The ventral setae (*ab*) of segment xi in one specimen only on the left side of the body on prominent elevated rounded glandular papilla of a lighter colour than the surrounding skin. In other specimen on one side of the body the setae of segment xi on the other of the segment xii on similar papillae (text-fig. 2*a*).

Septa in the anterior part of the body not thickened. Last hearts in segment xi. Gizzard in segments xvii, xviii. Intestine with calciferous glands in segments xi-xiii.

Clitellum saddle-shaped, with indistinct intersegmental furrows, extending over segments xxx-xxxv (=6). Puberty " walls " well marked, extending over the segments $\frac{1}{2}$ xxx-$\frac{1}{2}$ xxxv, close over the lines of setae *b*. Male pores in the form of big transverse slits on segment xv with large elevated glandular areas extending on segments xiv and xvi, and obliterating the intersegmental furrows (text-figs. 2 *a*, *b*).

Two pairs of free testes and funnels in segments x, xi. Two pairs of very small, simple seminal vesicles in segments xi, xii. Two pairs of spermathecae opening in intersegmental furrows 9/10 and 10/11 in line of setae *cd*. The ampullae are large, sessile, without a prominent duct.

The new species of *Eophila* described above is allied to *E. tyrtea* (Ribauc.), but differs in the presence of spermathecae, form of male pores and position of first dorsal pore.

Bimastus tenuis (Eisen).

Kodaikanal, Palni Hills, S. India. Worms seen to live in tubes formed by their slime. Dr. S. L. Hora coll., 60 specimens.
Fern Hills, Nilgiris, S. India. Dr. S. L. Hora coll., 8 specimens.
Asni River near Junga, Simla Hills, W. Himalayas; alt. 4,000 ft. Dr. B. Chopra coll., 1 specimen.

Among the great number of examined specimens from the first locality I found some with well developed spermathecae, this is not often the case in *B. tenuis*, as it normally does not possess these organs. One specimen presented 2 pairs of fully developed spermathecae in the line of setae *c*, the other only one and one duct without the ampulla on the left side of the body in intersegmental furrows 9/10 and 10/11. Three other specimens had on the left or right side only one spermatheca with the ampulla situated in intersegmental furrow 9/10 or 10/11. Similar cases have been described by Smith (1917, 1928) and the author (1935*a*; 1936) in specimens from the United States and France and by Eisen and Michaelsen in *B. norvegicus* (Eisen) which I (1935*a*, 1936) regard as a synonym of *B. tenuis* (Eisen).

The clitellum in Indian specimens usually extends over segments xxvi-xxxi, but in one case (from Asni River, Simla Hills) over segments xxiv-xxx. The tubercula of puberty are developed in many cases, especially in the specimens with well developed spermathecae; they usually extend over segments xxix-xxx.

Bimastus parvus (Eisen).

A cultivated field near Uts or "Hot Springs", Lutkuh Valley, Chitral. Dr. B. Chopra coll., 1 specimen.
Ramram Gol below Arandu, Chitral. Dr. B. Chopra coll., 5 specimens.

Octolasium cyaneum (Sav.).

Murree near Sunny Bank, W. Himalayas, Punjab; alt. 6,500 ft. Dr. H. S. Pruthi coll., 2 specimens.
Cart Road, Murree, W. Himalayas, Punjab. Dr. H. S. Pruthi coll., 1 specimen.

This species is widely distributed in Europe, but has also been found in Australia and South America (Argentine). From India it is being recorded for the first time.

Octolasium lacteum (Örley).

Dhar, Murree Sub-Divn., W. Himalayas, Punjab. Dr. H. S. Pruthi coll., 9 specimens.
Cart Road, Murree, W. Himalayas, Punjab. Dr. H. S. Pruthi coll., 4 specimens.

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NOTES ON THE LARVA AND PUPA OF *AMPHIPSYCHE INDICA* MARTYNOV [INSECTA: TRICHOPTERA].

By H. A. HAFIZ, *Ph.D.* (*London*), *D. I. C.* (*London*), *Assistant Superintendent, Zoological Survey of India, Calcutta.*

INTRODUCTION.

Large numbers of larvae and pupae of a Trichopteran of the family Hydropsychidae were found attached to the walls of the main storage tanks and filter-beds of the main water pumping station at Pulta which is situated on the southern bank of the river Hooghly about seventeen miles north of Calcutta. They were met with during May, 1936, in the course of an investigation of the biology of the aquatic fauna of the main pumping station undertaken by the Zoological Survey of India at the instance of the Calcutta Corporation. The adults of the species, which were sent to Dr. A. B. Martynov, Moscow, have been identified as *Amphipsyche indica* Martynov[1]. The earlier stages of no species of the genus *Amphipsyche* McLachlan have, so far as I am aware, been described, and as *A. indica* appears to have some importance in connection with the filter-beds, I have thought it opportune to record my observations on its biology and describe its larval and pupal stages.

I am obliged to Dr. A. B. Martynov, U.S.S.R., for the identification of the adult Caddis-flies, and to Dr. Baini Prashad, Director, Zoological Survey of India, for help in preparing this paper for the press.

DESCRIPTION.

Larva (Text-fig. *a*).—Length 12 mm., width 3 mm. General colouration greenish approaching Roman green dorsally; ventrally somewhat lighter. All horny parts of head and thorax yellowish brown with black markings in the lateral margins of pro-, meso-, and metathorax. Thorax as a whole paler than head, which is dark brown; dorsal surface flattened forming a broad disc or the false clypeus, beset with numerous closely placed bristles and enclosed by a heavy horse-shoe-shaped carina. The carina crosses the true clypeus near its apex, but does not distinctly set off the small triangle characteristic of genera like *Macronema* Pict. Long bristles at the anterior corners of head just above the lateral eyes, which are of a dark brown colour. Mandibles dark brown, with long stiff hairs at the outer margin posteriorly. Right mandible with five teeth on its inner margin, fifth situated about the middle (Text-fig. *b*). Left mandible with six teeth, fifth and sixth situated close together about the middle (Text-fig. *c*). The first tooth in both the mandibles is raised above the second and pointed; the rest in one plane and blunt; sixth tooth of left mandible with a dent in the middle.

Legs yellowish brown, beset with numerous hairs. Coxae with black markings at points of attachment to body. Short accessory claws present in all legs. Accessory claws of prolegs absent.

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[1] Martynov, A. B., *Rec. Ind. Mus.*, XXXVII, p. 199 (1935).

Thoracic and abdominal tracheal gills present. Anal gills absent. The following table shows the distribution and arrangement of gills on the left side of the larva:

	Thoracic segments.		Abdominal segments..							
	II	III	I	II	III	IV	V	VI	VII	VIII
D.	*nil*	1	*nil*	2, 1	2, 1	2, 1	2, 1	2, 1	2, 1	2
L.	*nil*	*nil*	1	2	2	2	2	2	2	*nil*
V.	1	1	1	1	1	1	1	1	*nil*	*nil*

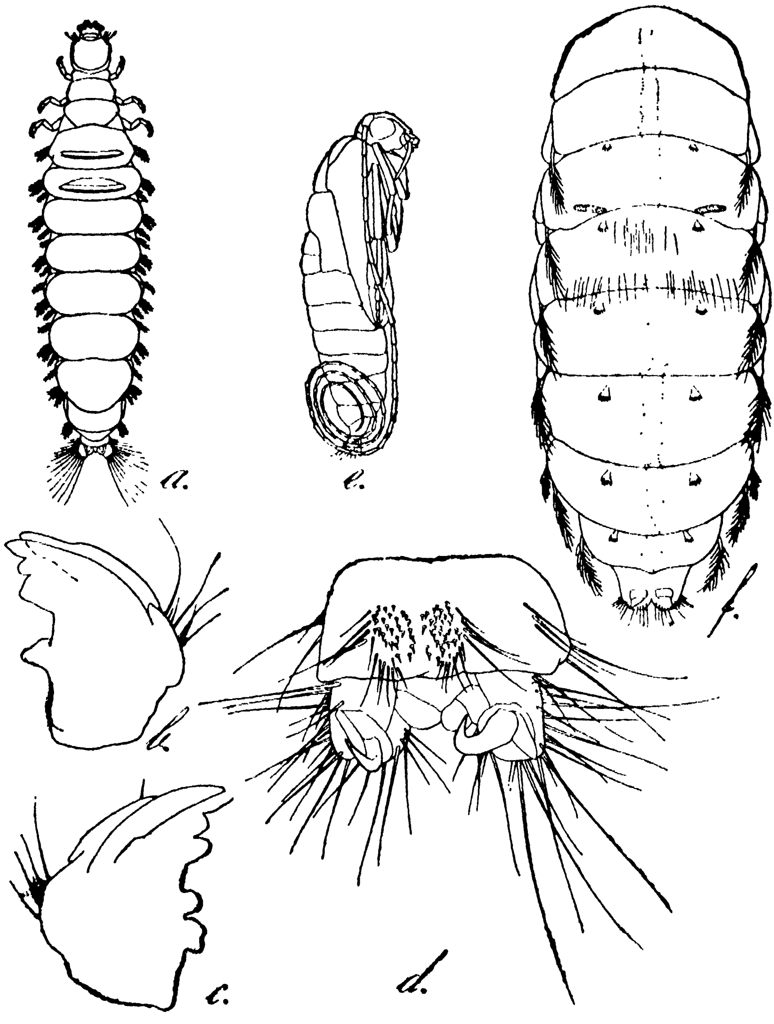
D.=Dorsal; L.=Lateral (half-way between D. and V.); V.=Ventral; 1.=single filamentous gill, and 2.=gill composed of two separate filaments.

The single filamentous "Dorsal" abdominal gills situated near the posterior margins of their respective abdominal segments and dorsad of the other "Dorsal" gills which are composed of two distinct filaments. The ninth abdominal segment bears ventrally two somewhat oval patches of short, spike-like, dark brown bristles; those forming the outer fringe are considerably longer than the middle ones (Text-fig. *d*).

Pupa (Text-fig. *e*).--Length 10 mm., width 2·5 mm. The pupae when removed from their sheaths are dull greenish to dirty whitish. Head and thorax not chitinized. Eyes large and well developed. Legs white, well developed and compactly placed on the ventral side. Antennae whitish, long, and closely pressed against the sides of the entire length of the body, ends curled up into coils at the posterior extremity. White leaf-like developing wings closely pressed against the sides of the thorax. The two oval patches of bristles on the ninth abdominal segment present in the larval stage have disappeared. Abdominal gills present though somewhat degenerate. Fourth abdominal segment dorsally hairy. Abdominal segments 3, 4, 5, 6, 7 and 8 bear dorsally on either side of the mid-dorsal line near the upper margin a pair of minute reddish pectinate structures lying flatly on the segments with the teeth of the combs pointed backwards. Segment 3 near the lower margin with a pair of narrow obliquely situated patches of minute reddish bristles in addition to the pair of pectinate structures (Text-fig. *f*). Long stiff hairs on the anal segment posteriorly. Mouth parts fairly well developed; mandibles folded on each other transversely like the blades of a penknife, with the right one anterior to the left.

Larval and pupal cases.—Length 11 mm., diameter 3·5 mm. The cases of both the larvae and the pupae are cylindrical and somewhat arched in the middle. They are made of some tough material, with minute sand grains mixed in it. Posterior end rounded and closed. Anterior end closed with a firmly attached disc-like plate in the pupae only. Both the disc and the rounded posterior end are provided with a number of minute slits in their middle. The cases are attached side by side like a honey-comb in two to three tiers.

Large mats of these cases were found attached to the sides and bottom of the outlet channel which discharges water from the final settling tank



Amphipsyche indica Martynov.

a. Dorsal view of larva, ×4 ; *b.* right mandible of larva, × 40 ; *c.* left mandible of larva, ×40 ; *d.* ventral view of the posterior extremity of larva showing the two ovalish patches of bristles on the 9th abdominal segment and the prolegs, ×30 ; *e.* side view of pupa, ×5 ; *f.* dorsal view of the abdominal segments of pupa showing the position of pairs of pectinate structures and patches of bristles on the third segment, ×12·5.

to the various filter-beds. Along with these mats of cases, some of them measuring 18 inches by 12 inches, colonies of the fresh water sponge, *Corvospongilla lapidosa* Ann., were found adhering to the sides and bottom of the outlet channel. A few larvae were also found living in the channels of the sponges. Large numbers of dead larvae and pupae were found in the intake chambers of the filter-beds. A few pupae were collected from the walls of the filter-beds. The larvae invariably perished in

aquaria in the laboratory and hence their feeding habits could not be studied.

Dense swarms of the adult *A. indica* were observed on 15th May 1936 at about 6-15 P.M. just before dark flying low over thick growth of plants in the compound of the water-works in the neighbourhood of the filter-beds and the final settling tank. Comparatively larger numbers of these were also attracted to light on this particular night.

The larva of *A. indica* shows characters common to the subfamily Macronematinae but differs from the genus *Macronema* Pict. in the absence of the small triangle set off on the dorsal surface of the head, where the carina or the false clypeus crosses the true clypeus near its apex. The closely related genus *Hydropsyche* Pict. differs from *Amphipsyche* McLachlan in the absence of the carina.

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CHANGES IN THE INTERNAL STRUCTURE OF THE AIR-BLADDER OF *PANGASIUS PANGASIUS* (HAM.) DURING GROWTH.

By K. KRISHNAN NAIR, *B.A.*

(From the Laboratories of the Zoological Survey of India.)

In the course of his taxonomic studies, Dr. S. L. Hora[1] found considerable variation in the form of the air-bladder of *Pangasius pangasius* (Ham.), and from an examination of the material in different stages of growth he was able to reconcile the divergent accounts of its structure by Taylor,[2] Day,[3] and Bridge and Haddon.[4] Further, when dealing with the correlation between the disposition of the liver and the kidney and the form of the air-bladder in *Pangasius*, he[5] indicated that under the pressure of the growing kidneys, the form of the air-bladder undergoes a series of changes. Dr. Hora's studies were, however, limited to the modifications in the external form of the air-bladder, but he recognised the need for a detailed study of the internal structure of the organ during growth. Being unable to devote much time to morphological work, Dr. Hora very kindly entrusted his material to me, and helped in collecting material of other stages from the Calcutta markets. I have thus been able to dissect specimens ranging in length from 91 mm. to 885 mm. In the following account of the structure of the air-bladder, I have followed the terminology of Bridge and Haddon. All the drawings reproduced here were made by me with the help of a Camera Lucida.

I am very grateful to Dr. Baini Prashad, Director, Zoological Survey of India, for affording me the necessary facilities for work in his department. The work has been carried out under the supervision and guidance of Dr. S. L. Hora, to whom I am indebted for the material, valuable suggestions and constant encouragement. My thanks are also due to Dr. T. N. Poddar, Professor of Biology, Carmichael Medical College, Calcutta, for his help in procuring a part of the material, and to Babu D. N. Bagchi, the senior Artist of the Zoological Survey of India for helpful suggestions in connection with the preparation of the illustration.

DESCRIPTION OF THE MATERIAL.

1. *Size of specimen: 91 mm. in total length.* (Text-fig. 1, *a* and *b*).

The air-bladder of a specimen 91 mm. in total length (fig. 1) consists of a large anterior portion which is like a normal bladder, and also of a posterior portion which is in the form of a caecum. The anterior portion is broad in front and oval behind. The posterior portion is very small

[1] Dr. Hora very kindly allowed me to see his manuscript on the revision of the Schilbeidae which is to be published in the *Records of the Indian Museum.*

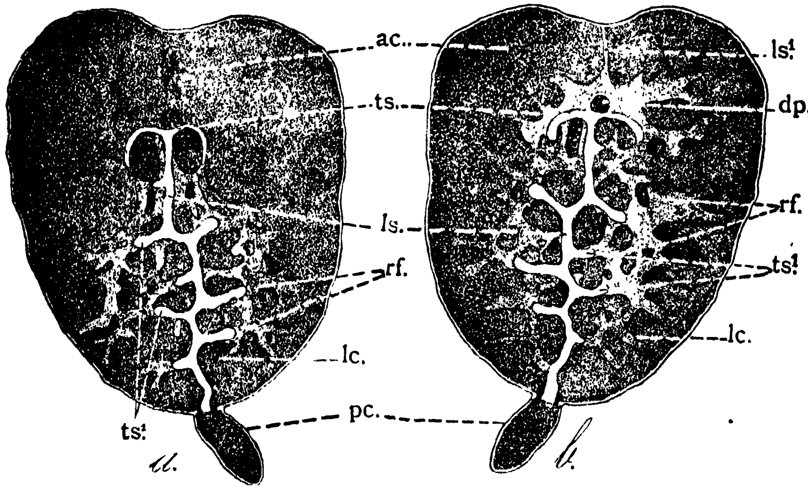
[2] Taylor, *Gleanings in Science*, p. 171 (1830).

[3] Day, *Proc. Zool. Soc. London*, p. 709 (1871).

[4] Bridge and Haddon, *Trans. Roy. Soc. London* (B) CLXXXIV, pp. 214-219 (1894).

[5] Hora, *Proc. Nat. Inst. Sci. India*, III, pp. 31-43 (1937).

and is covered dorsally by the kidneys but exposed ventrally. The anterior portion is divided internally into one short but broad anterior chamber (*ac.*) situated in front of the transverse septum (*ts.*) and two lateral chambers, (*lc.*) one on either side of the longitudinal (*ls.*) septum.



TEXT-FIG. 1.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 91 mm. in total length. ×4.

a. Dorsal half. *b.* Ventral half.

ac.=the anterior chamber; *ar.*=annular ridges; *dp.*=opening of the ductus pneumaticus into the bladder; *lc.*=lateral chamber; *ls.*= primary longitudinal septum; *ls.*[1] secondary longitudinal septum; *pc.*=caecum; *rf.*=root-like bundles of fibres; *ts.* primary transverse septum; *ts.*[1]= secondary transverse septa; *vp.*=vertical pillars.

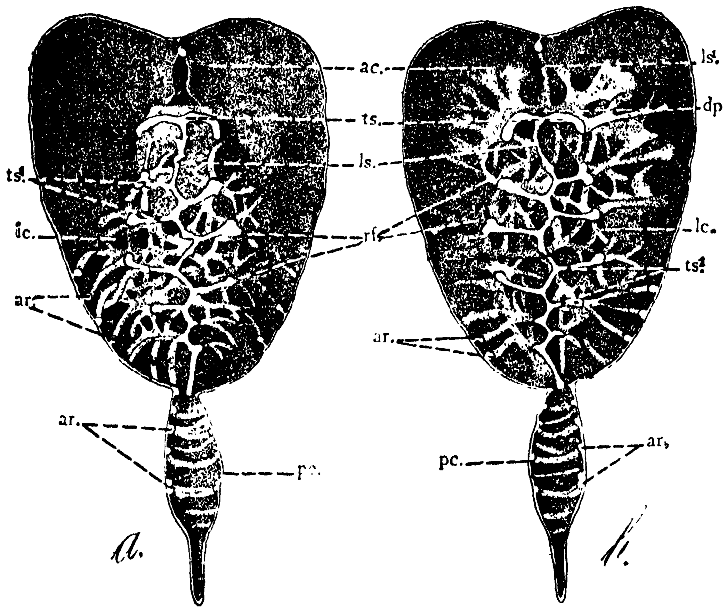
From the thick transverse septum, another thin longitudinal septum (*ls.*[1]) grows forward and meets the anterior wall of the bladder. This new septum is confined to the ventral half of this portion of the bladder, and hence it does not bring about a division of the anterior chamber into two. This structure, which may be termed the secondary longitudinal septum, is not recorded by Bridge and Haddon. There is in addition a hollow pneumatic duct which connects the bladder with the oesophagus. The duct (*dp.*) opens into the bladder on its ventral wall just in the middle and in front of the primary transverse septum. The cavities of the two lateral chambers are subdivided and greatly broken up by the formation of numerous secondary transverse septa (*ts.*[1]) which grow out from the sides of the primary longitudinal septum and laterally terminate before reaching the outer walls of the chambers. The secondary septa are further strengthened, and the spaces they enclose additionally sacculated by the growth of root-like bundles of fibres (*rf.*) which extend in between the septa. The growth of the root-like fibres is more vigorous in the ventral half of the bladder (fig. 1 *b*) than in the dorsal. In the ventral half very little space is left free, as most of the area is occupied by septa and fibrous tissue.

The posterior portion of the bladder, *i.e.*, the caecum (*pc.*), communicates anteriorly with both the lateral chambers but terminates blindly

behind. The communication is effected by two holes, one on either side of the longitudinal septum. The walls of the caecum are free from ridges or any other thickenings. It may also be noted that the walls of the posterior portion of the bladder are somewhat thickened and more opaque. The two antero-lateral pockets bulge dorsally and possess transparent walls. At this stage, the walls of the air-bladder are in contact with the lateral cutaneous areas, there being no layer of fat between the two. Anteriorly the right half of the bladder is a little longer than the left. The kidneys extend along the sides of the bladder to more than half of its length.

2. *Size of specimen : 143 mm. in total length* (Text-fig. 2, *a* and *b*).

The anterior portion of the air-bladder of a specimen 143 mm. in total length is similar in shape to the one described above, with the exception that the number of the secondary transverse septa (*ts.*[1]), which arise from the longitudinal septum (*ls.*), and of the root-like bundles of fibres (*rf.*) at the ends of the secondary transverse septa is greater.



TEXT-FIG. 2.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 143 mm. in total length. ×3½.

a. Dorsal half. *b.* Ventral half.

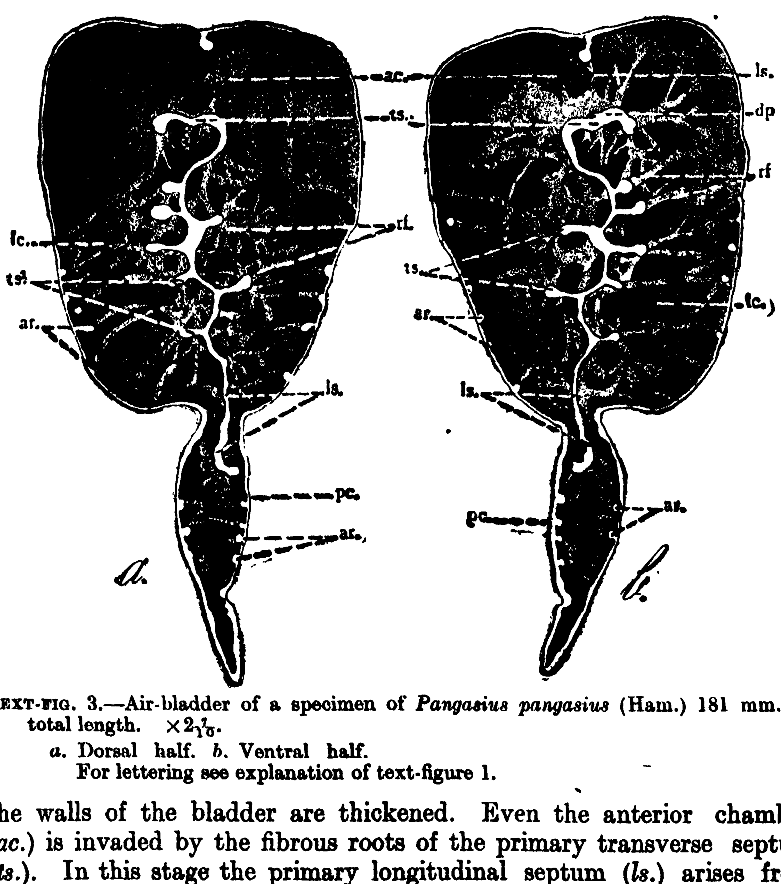
For lettering see explanation of text-figure 1.

These root-like bundles of fibres along with the few annular ridges (*ar.*), which are dorsoventrally placed along the sides of the bladder towards its posterior end, contribute to the obliteration of the space inside the bladder. The secondary longitudinal septum (*ls.*[1]), which was just noticeable in the earlier stage described above, is more prominent. It is in the form of a ring, placed dorsoventrally in the median portion of the anterior wall.

The posterior portion of the bladder (*pc.*) is now considerably longer and its posterior end almost extends to the base of the ventral fins. The tubular caecum is enclosed by the kidneys on the sides, but is exposed ventrally. It could also be seen at least in one place dorsally. The longitudinal septum does not extend into the caecum. The caecum is no longer a simple structure as its cavity is being filled up and the walls are further thickened and strengthened by a few annular ridges (*ar.*). Besides these ridges, there are other fibrous thickenings which arise from the ventral and dorsal walls. Towards the posterior end, the caecum is suddenly narrowed. The narrow region is devoid of ridges. There is very thin layer of fat between the bladder and the lateral cutaneous areas towards the posterior end of the latter, but towards its anterior end the fat layer is absent, and consequently the skin comes in contact with the bladder in that region.

3. *Size of specimen: 181 mm. in total length* (Text-fig. 3, *a* and *b*).

In the anterior portion of the bladder, there are a number of secondary transverse septa (*ts.*[1]) and root-like fibrous growths (*rf.*). The annular ridges (*ar.*) along the sides are more numerous. Practically everywhere,



TEXT-FIG. 3.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 181 mm. in total length. $\times 2\frac{1}{10}$.
a. Dorsal half. *b.* Ventral half.
For lettering see explanation of text-figure 1.

the walls of the bladder are thickened. Even the anterior chamber (*ac.*) is invaded by the fibrous roots of the primary transverse septum (*ts.*). In this stage the primary longitudinal septum (*ls.*) arises from the left extremity of the transverse septum, and not from the middle

of it, as is generally the case. The longitudinal septum, at this stage, extends into the cavity of the caecum for a very short distance.

The tubular caecum (*pc.*) originates entirely from the left half of the bladder instead of from the median point. It is covered on the sides by fairly thick layers of fat and extends as far as the base of the ventral fins. The walls of the caecum are strengthened by a number of annular ridges (*ar.*). A short distance in front of the posterior end, the wall on one side of the caecum is constricted. This may be an indication for the formation of an additional chamber.

There is a thin layer of fat between the walls of the bladder and the lateral cutaneous areas so that the walls are not directly in contact with the skin. There is an uneven layer of fat which covers the whole of the ventral surface of the bladder and a portion of the dorsal surface as well. The posterior half of the anterior portion of the bladder is somewhat compressed, probably owing to the lateral pressure exerted by the kidneys.

Judging from Bridge and Haddon's[1] description of the bladder, it seems probable that they had a specimen intermediate in size between the last two stages described above.

4. *Size of specimen : 205 mm. in total length.*

The air-bladder of a specimen 205 mm. in total length is similar in shape to the one described above, with the exception that the transverse septa, root-like fibres, and the length of the caecum are more pronounced. The tubular caecum extends backward to a fourth of the length of the anal fin and is externally divided into three chambers. The caecum is very much strengthened by annular ridges.

Day's[2] description of the air-bladder appears to correspond with the above description to a great extent.

5. *Size of specimen : 303 mm. in total length* (Text-fig. 4, *a* and *b*).

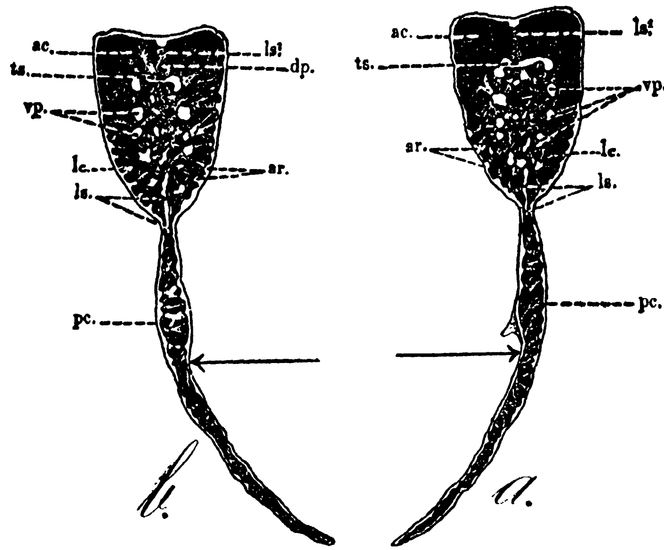
In a specimen 303 mm. in length, the air-bladder is long and narrow ; its walls are thick and hard. The anterior chamber (*ac.*) is very narrow and the lateral chambers (*lc.*) are filled with annular ridges (*ar.*) and fibrous thickenings. The longitudinal septum is absent as such, but it is broken up into a number of vertical pillars (*vp.*) which fill up the space inside the bladder. The longitudinal septum (*ls.*) is present only near the junction of the two portions of the bladder.

The tubular caecum is very long, about twice the length of the anterior portion of the bladder. The posterior half of the caecum is lodged within the ventral caudal musculature and the end of the caecum extends backward to more than a fourth of the length of the anal fin. The cavity of the caecum is almost filled by annular ridges, transverse and longitudinal thickenings.

There is a thin layer of fat between the walls of the bladder and the lateral cutaneous areas. A layer of fat is also present on the ventral surface of the bladder. The caecum gives off a spine-like projection from its dorsal wall, at about its middle. The dorsal half of the bladder

[1] Bridge and Haddon, *Trans. Roy. Soc. London*, (B), CLXXXIV, pp. 214-219 (1894).
[2] Day, *Proc. Zool. Soc. London*, p. 709 (1871).

(fig. 4, *a*) is comparatively less invaded by the fibrous thickenings and annular ridges.



TEXT-FIG. 4.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 303 mm. in total length. $\times\frac{1}{4}$. The portion of the caecum, beyond the arrow is accommodated in the caudal muscles.

a. Dorsal half. *b*. Ventral half.

For lettering see explanation of text-figure 1.

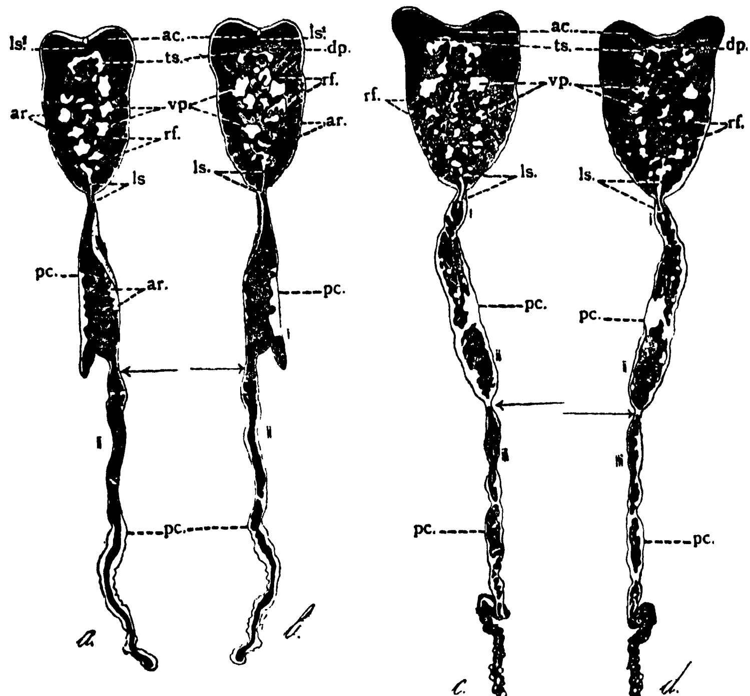
6. *Size of specimen : 353 mm. in total length.*

The air-bladder of this specimen is similar in all details to the one described above with the exception that the tubular caecum is definitely divided into two separate chambers by a constriction of the walls of the caecum. The caecum, which is folded on itself towards the posterior end, as shown in the case of the last stage, extends backward as far as the posterior end of the anal fin. The portion of the caecum, which is lodged in the muscles of the tail, is comparatively harder than the rest of it.

7. *Size of specimen : 460 mm. in total length* (Text-fig. 5, *a* and *b*).

The anterior chamber (*ac.*) is very narrow. The primary transverse septum (*ts.*) is very broad, and including its fibrous roots it is nearly as broad as the anterior chamber. There are no lateral compartments as such, for the space is filled by stout vertical pillars (*vp.*). These vertical pillars are roughly arranged in three rows, and probably represent the longitudinal septum in the middle and the end portions of the secondary transverse septa at the sides. A small portion of the longitudinal septum (*ls.*), the only remaining representative of the original primary longitudinal septum, extends into the caecum. The secondary longitudinal septum (*ls.*[1]) is still represented here in a degenerating stage. The fact that it is degenerating is clearly shown by its absence in a bladder of a larger specimen, as shown below. There are very stout annular ridges (*ar.*) along the sides which strengthen the walls of the

bladder. In the dorsal half of the bladder (fig. 5, *a*) there are two regions along the sides, towards the anterior end which have a free space. These



TEXT-FIG. 5. *a.* & *b.*—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 460 mm. in total length. $\times \frac{3}{8}$. *a.* Dorsal half. *b.* Ventral half.

c. & *d.* Air-bladder of another specimen of *Pangasius pangasius* (Ham.) 885 mm. in total length. $\times \frac{3}{16}$. *c.* Dorsal half. *d.* Ventral half.

The portion of the caecum, beyond the arrow is accommodated in the caudal muscles.

For lettering see explanation of text-figure 1.

portions bulge upward and are accommodated in bony recesses on the sides of the vertebral column.

The tubular caecum (*pc.*) is covered by a layer of fat for about half of its length, and extends as far back as three-fourths of the length of the anal fin. About the middle of its length, it gives off a short blind caecum towards the right side. The caecum at this stage is much complicated and is divided into more than one chamber. Of these chambers, only the first two (i and ii) are connected internally with each other and with the anterior portion of the bladder as well. There are numerous annular ridges (*ar.*) and other thickenings on the walls. The caecum is very long, shallow and tough, with the walls greatly thickened. Towards its posterior end, there are two places where the caecum is somewhat compressed.

There is a layer of fat between the walls of the bladder and the lateral cutaneous areas. The ventral surface of the bladder is covered by a

thick layer of fat which extends to half of the dorsal surface as well. The cavity of the pneumatic duct towards the oesophageal end is almost obliterated by the development of fibrous tissue from its walls. The bladder is relatively narrower and harder.

8. *Size of specimen: 536 mm. in total length.*

The structure of the air-bladder of a specimen 536 mm. in total length agrees, more or less, with the above description, except that the secondary longitudinal septum is altogether absent, and the caecum is definitely divided into two separate chambers, one broad and the other narrow. The whole of the narrow chamber is lodged in the caudal muscles. The caecum extends backward to about four-fifths the length of the anal fin. The walls of the bladder and the caecum are very hard and tough.

9. *Size of specimen: 885 mm. in total length* (Text-fig. 5, *c* and *d*).

The anterior wall of the bladder has a tendency to fatty degeneration. The anterior portion of the bladder is oval in shape with posterior end slightly narrower. The short, but broad anterior chamber (*ac.*), is greatly reduced. The primary transverse septum (*ts.*) is not fully developed and lies immediately behind the anterior wall of the bladder. The secondary longitudinal septum is absent. The walls of the bladder are strengthened by annular ridges (*ar.*) and are very hard to the touch. A small length of the greatly reduced longitudinal septum (*ls.*) extends into the cavity of the caecum.

The posterior portion of the bladder (*pc.*) is very long and reaches almost to the end of the tail region. It is accommodated in the ventral caudal muscles which are very closely applied to it. The walls of the caecum are very thick and the cavity inside is nearly filled by a number of strong and stout ridges which arise without any orderly arrangement. Towards the posterior end, the caecum is folded on itself, and the outer walls are covered with many stout and strong knobs. The caecum may apparently be divided into eight chambers; only the first three (i, ii and iii) are in communication with one another, and with the anterior portion of the bladder. The other chambers of the caecum are variously filled with fibrous growths.

There is a layer of fat between the walls of the bladder and the lateral cutaneous areas. The ventral wall of the bladder is closely attached to the dorsal wall of the abdominal cavity. The anterior portion of the bladder is white and shining while the caecum is dirty white in appearance. The oval plates of the "elastic spring" apparatus are well accommodated in the two hollow spaces developed on the anterior wall of the bladder. These spaces are very thin though the whole bladder is very hard to the touch. The pneumatic duct has an opening (*dp.*) into the bladder, but its opening to the oesophagus is not clear. However, a very small hole, not larger than a pinprick, is seen on the wall of the oesophagus.

Judging from Taylor's[1] description of the bladder, it seems probable that he had a specimen intermediate in size between the last two stages described above.

[1] Taylor, *Gleanings in Science*, p. 171 (1830).

ON THREE CHALCIDOID PARASITES OF COTTON BORER-BEETLES FROM SOUTH INDIA.

By T. V. RAMAKRISHNA AYYAR *B.A., Ph.D., Late Government Entomologist, Agricultural Research Institute, Coimbatore,* AND M. S. MANI, *Assistant, Zoological Survey of India, Indian Museum, Calcutta.*

While studying the bionomics of the Cotton Borer-beetles, *Sphenoptera gossypii* Kerr. and *Pempheres affinis* Fabr., in South India, the senior writer bred, among others, three interesting Chalcidoid parasites of these beetles. One of these, *Euderus gossypii* Ferr., is the well known parasite of *Sphenoptera gossypii* Kerr. in Sudan and Punjab ; and the other two are new to science. In an earlier paper[1] Ayyer gave a brief account of the biology of the parasites and also discussed the possibilities of using them as natural control of the Cotton beetles, and in this paper the new species are described together with additional notes on all the species.

Family PTEROMALIDAE.

Genus **Neocatolaccus** Ashmead.

1864. *Catolaccus, (partim)*, Ashmead, *Bull. Ohio Expt. Sta.*, I, p. 161.
1904. *Neocatolaccus*, Ashmead, *Mem. Carnegie Mus.*, I, (4), p. 320.
1909. *Neocatolaccus*, Schmiedeknecht, *Gen. Ins.*, fas, 97, p. 356.
1909. *Neocatolaccus*, Masi, *Boll. Lab. Zool. Portici*, III, p. 138.

The genus *Neocatolaccus* was erected by Ashmead in 1904 with *Catolaccus tylodermae* Ashm. as the type. Since then five more species have been described from different parts of the world : *australensis* Gir.[2] from Australia, *subviridis* Gir.[3] from Paraguay, *livii* Gir.[4] from Porto Rico, *syrphidis* Gir.[5] from Trinidad and *sphenopterae* Ferr.[6] from Sudan. No species of the genus has so far been described from India.

According to Ashmead and Schmiedeknecht there are in this genus *three* ring joints in the antennae in *both* the sexes. On behalf of Masi[7], Crawford re-examined the type specimen of *N. tylodermae* (Ashm.) in the U. S. National Museum, Washington, and found only *two* ring joints in both sexes. Masi erected the genus *Pseudocatolaccus* for forms having three ring joints in the female and two in the male. Ashmead describes *Neocatolaccus* as having a distinct median carina on propodium, while according to Masi *Pseudocatolaccus* is without a carina. Females of the closely related genera *Metapachia* Westw. and *Parapteromalus*

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[1] Ramakrishna Ayyar and Margabandhu, *Madras Agric. Journ.*, XXIV, pp. 102-107, (1936).
[2] Girault, *Mem. Queensland Mus.*, II, p. 306, (1913).
[3] Girault, *Archiv Naturgesch.*, LXXXVI, A, Heft 6, p. 56, (1913).
[4] Girault, *Insec. Inscit. Menstr.*, IV, p. 112, (1916).
[5] Girualt, *Ent. News*, XXVII, p. 403, (1916).
[6] Ferriere, *Bull. Ent. Res.*, XXII, p. 130, (1931).
[7] Masi, *Boll. Lab. Zool. Portici*, III, p. 138, (1909).

Ashm. have two ring joints and one propodial carina. Males of *Parapteromalus* have also two ring joints but no propodeal carina. In *Diglochis* Först. there are two ring joints and one propodial carina in both the sexes. It is possible that several of these genera might prove to be synonyms. Both *N. sphenopterae* Ferr. and the new species described below agree with *Pseudocatolaccus* in having three ring joints in the antennae but differ in the median carina on propodeum. As it has not been possible to correctly define the exact limits of these closely related genera in the absence of types, the new species is provisionally referred to the genus *Neocatolaccus*.

Neocatolaccus indicus, sp. nov.

This new species bears a general resemblance to *N. sphenopterae* Ferr. but differs in the following characters:

Frons reticulately sculptured, the striations which diverge upwards from the lower border of clypeus rather sharply defined and prominent; antennae inserted just at the level of the lower borders of eyes; club of antennae longer than the two preceding segments combined; parapsidal furrows continue a little beyond the middle of mesonotum, though not reaching its posterior edge; spiracles on propodium small and almost rounded; fore wings with a slight discal ciliation at base; marginal vein less than half the length of submarginal vein.

Female.—2·7-3·0 mm. long. Head very dark green, almost black; rounded in the front view; frons swollen; sculpture closely reticulate; striations of clypeus very prominent; cheek large, almost as broad as eyes; the front ocellus placed at the apex of scapal furrows, the lateral ones closer to the front one than to the eye border. Antennae generally brown, inserted just at the level of the lower borders of eyes; scape yellowish brown, thin, very slightly curved; pedicel stouter apically than basally, about twice as long as wide; ring joints three, the first two small and the third much wider and almost twice longer; first funicular segment about twice the length of pedicel and somewhat stouter; second funicular segment about half the length of first; the following three segments somewhat shorter, but each nearly equal, and gradually growing wider apically; club triarticulate, stouter and somewhat distinctly longer than the two preceding segments combined.

Thorax very dark green; pronotum reticulately sculptured; mesonotum wider than long, reticulately punctate, with parapsidal furrows reaching beyond its middle though not actually touching the posterior edge; scutellum a little shorter than its posterior breadth, sculpture similar to that of mesonotum; propodium shiny green, with prominent median carina and lateral spiracular sulci, spiracles small and almost rounded. Fore wings with a slight discal ciliation at base; marginal vein somewhat less than half the length of the submarginal; post marginal narrower and shorter than the marginal; stigmal about two thirds the marginal. Legs generally brown or yellowish brown.

Abdomen oval, much pointed posteriorly, longer than thorax, third segment not short.

Holotype.—One female dissected on three slides, in the collections of the Zoological Survey of India, Indian Museum, Calcutta, No. 1572/H 3. Coll. T. V. Ramakrishna and V. Margabandhu, Coimbatore, 1932.

Host.—*Pempheres affinis* Fabr.

Family EULOPHIDAE.

Euderus gossypii Ferriere.

1931. *Euderus gossypii*, Ferriere, *Bull. Ent. Res.*, XXII, p. 132.

This species was originally described by Ferriere from Sudan, Africa and Lyallpur, Punjab, as parasitic on the larva of *Sphenoptera gossypii* Kerr. in cotton stems. It is recorded here for the first time from South India; it was bred from the same host at Bellary in the month of February 1932.

Euderus pempheriphila, sp. nov.

This new species is easily distinguished from the closely related *E. gossypii* Ferr. by the relatively stouter and longer club of antenna of female.

Female.—About 2 mm. long. Head very dark green, almost black, often more or less metallic green or blue, purplish on the vertex, transverse, rounded in front view, sparsely punctate and pubescent. Antennae inserted at the level of the lower borders of eyes; pedicel dark green; ring joint very short and transverse; first segment of funicle nearly equal to pedicel, but very slightly broader, somewhat longer than broad; the following three segments nearly equal to the first; also second as long as broad, third and fourth very slightly broader than long; club about one and half times the combined length of the third and fourth funicular segments, much broader, triarticulate, the third segment conically produced and with a small nipple-like spine apically.

Thorax dark green, shagreened; scutellum distinctly broader than long. Propodium very short in the median line and with a distinct median carina; spiracles rounded. Marginal vein slightly longer than submarginal, somewhat thicker basally than apically; post marginal vein distinctly longer than stigmal vein.

Holotype.—One female dissected on a slide, in the collections of the Zoological Survey of India, Indian Museum, Calcutta, No. 1573/H 3. Coll. T. V. Ramakrishna, Coimbatore, 1932.

Host.—*Pempheres affinis* Fabr.

NOTE.—Ballard[1] refers to a Chalcid grub parasitising the larva of *P. affinis* at Coimbatore; it is possible he is referring to the larva of this species.

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[1] Ballard, *Mem. Dept. Agric. Ind., Ent. Ser.*, VII, p. 245, (1921); *Rep. Proc. Fourth Ent. Meet. Pusa*, p. 24, (1921).

ON A NEW SPECIES OF NEOECHINORHYNCHUS PARASITIC ON *MUGIL CEPHALUS* LINN. FROM THE CHILKA LAKE.

By T. N. PODDER, *M.Sc.*, *M.B.*, *Professor of Zoology, Carmichael Medical College, Calcutta.*

I recently examined the intestinal contents of a few fairly grown up specimens of *Mugil cephalus* Linn. from the Chilka Lake, Orissa, obtained from the local market. All the fishes examined were heavily infested with Acanthocephalan parasites. In one specimen the number of parasites was as high as 112. On examination these parasites proved to belong to a new species, which is described below under the name *Neoechinorhynchus chilkaensis.*

I take this opportunity of recording my sincere thanks to Dr. Baini Prashad, Director, Zoological Survey of India, Indian Museum, Calcutta, for the facilities for work ; to Dr. Sunder Lal Hora, Assistant Superintendent, Zoological Survey of India, for the identification of the host and to Mr. M. N. Datta of the Zoological Survey of India for his valuable suggestions.

Neoechinorhynchus chilkaensis, sp. nov.

The proboscis (fig. *a*), is globular in shape with a very short neck. It is covered with three rows of hooks, six in each row. The hooks of the anterior row are relatively much larger and stouter than those of the other rows. The proboscis sheath is a thin and single walled muscular sac attached to the base of the proboscis.

The nervous system consists of a single nerve ganglion with a few nerve fibres situated posteriorly within the wall of the proboscis sheath. These nerve fibres supply the body wall of the worm.

The body is lanceolate and cylindrical and devoid of spines. Its walls consist of a layer of cuticle outside, then the thick submucosa which is traversed by numerous canals and canaliculi which form the lacunar system (Verma and Datta, 1929)[1] which is followed by the transverse and longitudinal muscle fibres. The transverse canals of the lacunar system are very prominent giving the appearance to the body of pseudosegmentation.

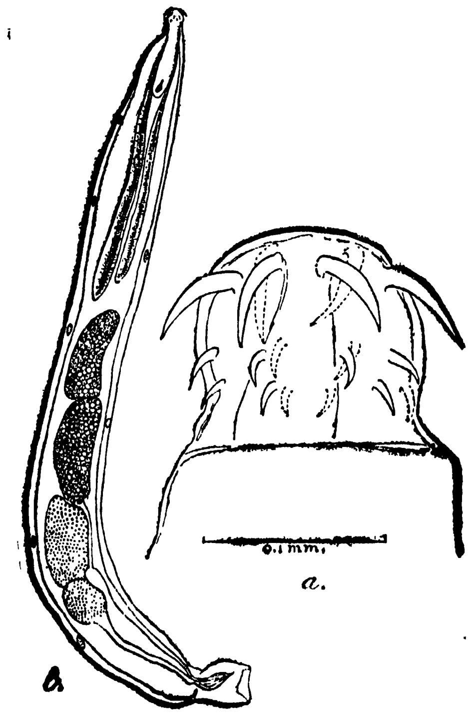
In the body wall there are subcuticular nuclei 4-5 on the mid-dorsal side and 2 on the mid-ventral side of the worm.

Male genitalia (fig. *b*), beginning just above the middle of the body, consist of a pair of ovoid testes, one behind the other, a pair of vasa efferentia, a vas deferens, a syncitial prostatic gland, a prostatic reservoir, a seminal vesicle, a muscular penis and a funnel-shaped bursa.

The vas efferens from each testis runs downwards and then swells a little near the angle formed by the posterior testis and the prostatic

[1] Verma, S. C. and Datta, M. N., Acanthocephala from Northern India, I. A new genus of Acanthocephala from a Calcutta fish. *Ann. Trop. Med. Parasit.* **XXII, pp. 483-498, (1929).**

gland before it joins with its fellow of the opposite side to form the vas deferens. This is a peculiarity of the genus *Neoechinorhynchus*.



Neoechinorhynchus chilkaensis sp. nov., (*a*) Proboscis showing arrangement of hooks. (*b*) Male specimen showing the genitalia, ×20.

The prostatic gland is a syncitial mass and empties its contents into the prostatic reservoir and the prostatic duct from the reservoir running for a short distance ends into the muscular penis situated at the top of the eversible bursa.

The seminal vesicle is of considerable size and is a thin-walled oval structure tapering downwards, finally opening into the base of the penis. The duct from the vas deferens also opens into the penis along with the duct of the seminal vesicle.

Female genitalia consist of a uterine bell, uterus, vagina and the vulva. The uterine bell is a thin-walled funnel-shaped organ retained in position by means of the genital ligament attached to the base of the proboscis sheath. A few guard cells are situated at the posterior end of the uterine bell whose function is to control the passage of mature ova. The uterus is a flabby tube which opens into the vagina. The vagina is a short and thick muscular tube which has two bands of strong muscles known as the vaginal sphincters, whose function is to allow the ova to pass in a single file. The vulva is the external thickened portion near the vaginal orifice and is situated at the ventral aspect of the worm near the posterior end.

Measurements.—Males 4·2—7·8 mm. × 0·20—1·03 mm.; Females 5·0—18·70 mm. × 0·31—1·08 mm.; Proboscis 0·121 × 0·11 mm.; Proboscis hooks anterior row 0·07 mm.; middle row 0·03 mm.; basal row 0·027 mm.; Proboscis sheath 0·46 × 0·14 mm.; lemnisci 1·85 × 0·11 mm.; and 1·61 × 0·11 mm.; Anterior testis 1·21 × 0·53 mm.; Posterior testis 0·77 × 0·59 mm.; Prostatic gland 1·69 × 0·66 mm.; Prostatic reservoir 0·44 × 0·26 mm.; Prostatic duct up to penis 1·03 mm.; vas deferens 1·14 × 0·20 mm.; Penis 0·11 × 0·4 mm.; Bursa 0·68 × 0·57 mm.; Female genitalia, Uterine bell 0·11 mm.; Uterus 0·21 mm.; Vagina 0·06 mm.; Ova 0·023 mm.; (in the male specimen which is 7 mm. long the anterior end of the anterior testis is 3 mm. from the anterior end of the proboscis).

Diagnosis.—From the table of allied species of *Neoechinorhynchus* Datta (1936)[1] it is evident that the main points of difference between the closely related species of *Neoechinorhynchus* and the new species, are the size and shape of body of the male and female specimens, the size and position of the genitalia, the size of the hooks and the number of subcuticular nuclei.

In the new species the males are generally smaller than the females, the proboscis sheath is single layered, the hooks of the anterior row are much longer and stouter than those of the other rows, the central nervous system is situated at the posterior portion of the proboscis sheath, the prostatic gland is a single syncitial mass, subcuticular nuclei and lacunar system and specially the transverse canals are well developed.

Host.—*Mugil cephalus* Linn.

Location.—Small intestine.

Locality.—Chilka Lake, Orissa (Bought from Calcutta market).

Type specimens are deposited in the collections of the Zoological Survey of India, Indian Museum, Calcutta.

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[1] Datta, M. N., Helminth parasites of fishes from North India, with special reference to Acanthocephala. *Rec. Ind. Mus.*, XXXVIII, pp. 211-229, (1936).

SKULL OF *VARANUS MONITOR* (LINN.).

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TABLE OF CONTENTS

	PAGE
1. Introduction	133
2. The Skull	135
I. General characteristics	135
II. The Cranium	135
(*a*) The occipital region	135
(*b*) The parietal region	144
(*c*) The frontal region	147
III. The Sense-Capsules	150
(*a*) The auditory capsules	150
(*b*) Bones in relation with the optic capsules	155
(*c*) Bones in relation with the olfactory capsules	157
IV. The Suspensorium	158
V. The Palate and the Upper Jaw	160
VI. The Lower Jaw	164
VII. Temporal arcades and fossae and other large vacuities	167
VIII. The Foramina of the skull	168
(*a*) Dorsal surface	168
(*b*) Ventral surface	169
(*c*) Lateral surface	169
(*d*) Posterior surface	170
(*e*) Longitudinal section	171
3. Streptostylism and Kinetism	172
4. Summary	173
5. List of References	173

1. INTRODUCTION.

The skull of *Varanus* forms a very suitable type of the Lacertilian skull and has therefore been figured in several current books on the comparative anatomy of vertebrates. For example, Bütschli (**3**, p. 274) figures the ventral, lateral and posterior aspects of the skull of *Varanus salvator*, but his description deals only with some of the leading features of the skull of Lacertilia as a whole as compared with the skulls of other reptiles. Similarly, Shimkewitsch (**8**, p. 122) gives the dorsal and ventral views of the skull of *Varanus niloticus*, but his description is very brief and includes only a few of the important characters of the skull. Amongst English authors, Reynolds (**7**, pp. 195 and 290) figures the dorsal, ventral and lateral views and also a longitudinal section of the skull of *Varanus varius*, but he too does not describe this skull as such, although he gives adequate descriptions of the skull of a chelonian and that of a crocodilian. Similarly, Thomson (**11**, p. 695) gives a diagram of the roof of the skull of a Varanid from a specimen, but his diagram is incompletely and even wrongly labelled and his description

is equally incomplete. Boulenger (**1**, p. 160), in the first edition of the *Fauna of British India* (Reptiles and Amphibia), gave rough sketches of the skull of *Varanus griseus*, which have been reproduced unaltered by Malcolm Smith (**10**, p. 396) in the second edition. These sketches are hardly complete and at places give a misleading idea of the relationships of bones and cartilages. Lastly, Goodrich (**5**, pp. 343 and 344), in his masterly work on the structure and development of vertebrates, gives the diagrams of Reynolds, but his account of the lacertilian skull is necessarily comparative and is based chiefly on that of *Lacerta*.

In all the first five books[1], the diagrams are original, *i.e.*, they have been specially drawn for each of these books. There are no standard diagrams in any memoir, from which they could be taken. Unfortunately, therefore, the diagrams vary and all of them are incomplete in several respects and even incorrect in some cases. As all these diagrams have apparently been made from dried skulls, the omission of important cartilaginous and even small bony parts of the complete skull is a specially weak feature of these diagrams. Further, no attention altogether has been paid to the large number of foramina through which the blood vessels and nerves pass.

In almost all the Indian Universities, *Varanus* is studied as a type of the Lacertilia; even where smaller types like *Calotes*, *Uromastix* or *Mabuia* are used for dissection, the skeleton studied is always that of *Varanus*. I began this work originally to identify the large number of foramina in the skull, but when I found that there was no satisfactory account of the skull, I decided to describe the complete skull, as I felt, firstly, that a description of the foramina alone would not be so useful as that of the whole skull, and, secondly, that I could correct and improve upon the diagrams which are extant in the commonly used text-books.

I have selected *Varanus monitor* (syn. *Varanus bengalensis*) as the type, as this species is the commonest and most extensively distributed throughout India, Ceylon, Assam and the greater part of Burma (**10**). In size it is the second largest species, the head and body being 750 mm. and the tail 1000 mm. The largest species is *Varanus salvator* (head and body 1000 mm. and tail 1500 mm.), but it is not found in the peninsula of India except in the extreme north-east, Eastern Bengal and the Eastern Himalayas (**10**). As the work involved a number of dissections and preparations displaying blood vessels and nerves, I have included a number of diagrams showing the relations of the bones with these structures in the hope that they would prove useful. Further, wherever possible, comparisons have been made with the skulls of *Sphenodon*, *Lacerta* and *Uromastix*.

I am indebted to Professor E. S. Goodrich of Oxford for kindly lending me Siebenrock's valuable paper on the skull of *Lacerta* from his private library. My best thanks are due to Mr. M. L. Bhatia who has rendered valuable assistance in the preparation of illustrations. Prof. A. H. Siddiqui has very kindly helped me in the dissections of some of the muscles.

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[1] I have not attempted to make an exhaustive search of all the books dealing with skull of *Varanus*, but have quoted these six only as representative examples.

2. THE SKULL.

I.—General characteristics.

The skull of *Varanus monitor* is pyramidal in shape, each of the dorsal, ventral and lateral surfaces being more or less triangular in outline; the posterior surface is also more or less triangular and forms, so to speak, the base of the pyramid, the apex being formed by the anterior pointed snout (united premaxillae). The skull is well ossified, although there are several tracts of cartilage even in the adult. It is a strong, compactly built structure, very well buttressed along its posterior and lateral aspects. The sutures between different bones remain clearly visible even in the adult, unlike these in *Lacerta* where they become obliterated in the adult skull.

The *cranium* or brain-box forms the axial part of the posterior two-thirds of the skull and is disposed, like the enclosed brain, in an obliquely elongated direction, higher in front and lower behind. The posterior part of the cranium enclosing the mid-brain and the hind-brain is more or less completely ossified but the anterior part surrounding the cerebral hemispheres and the diencephalon is ossified only dorsally, remaining partly membranous and partly cartilaginous along the greater part of its ventral and lateral aspects. At the extreme anterior end, however, the olfactory stalks are again enclosed completely in a bony tube. The *auditory capsules* are completely ossified and are intimately united with the occipital region of the cranium. The *orbits* are large and are well protected by bones; they are separated from each other by an extensive *inter-orbital septum*, which is largely cartilaginous but partly membranous. This septum lies beneath the anterior part of the cranial cavity all along its length and even extends forwards as the *internasal septum*. The *olfactory capsules* are also large and lie immediately in front of the cranial cavity; they are partially surrounded by bones latero-posteriorly but are mainly enclosed in large cartilaginous capsules along the greater part of their extent. The united pre-maxillae form the rostrum.

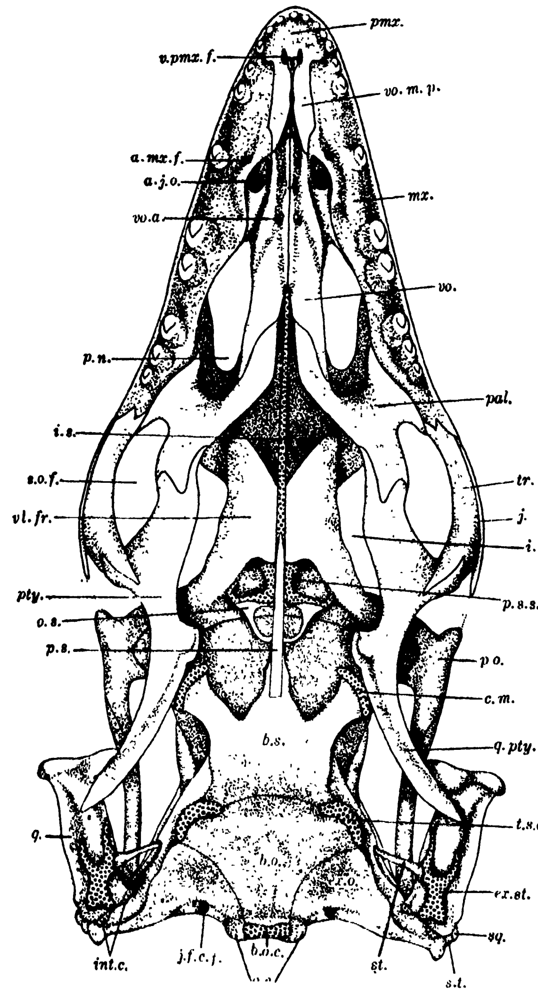
II.—The Cranium.

(*a*) *The Occipital Region.*

The *occipital region* is almost completely ossified and lies dorsally at a lower level than the parietal and frontal regions in front. It consists of four bones, (*a*) the basi-occipital, (*b*) the paired ex-occipitals, and (*c*) the supra-occipital, all of which remain distinct and take part in surrounding the foramen magnum. The single median *occipital condyle* (figs. 1, 6) is crescentic in outline and is distinctly tripartite, the median piece being formed by the posterior end of the basi-occipital and the two lateral pieces by the posterior ends of the two ex-occipitals. The median basi-occipital piece of the condyle (*pars condyloidea*) is the smallest and is covered over by a thin, scale-like, elliptical piece of calcified cartilage which has a smooth surface and a milk-white appearance. The only other cartilage present in this region is the *cone-shaped cartilage* (*processus ascendens*) at the anterior border of the supra-occipital (*vide infra*). All

the four bones of the occipital region are ossifications of the chondrocranium (replacing bones).

The median *basi-occipital* (fig. 1) forms a more or less triangular flat plate, broad in front but narrow and pointed behind. Its anterior border,



TEXT-FIG. 1. A ventral view of the skull of *Varanus monitor* (×*ca.* 2).

a.j.o., aperture for the Jacobson's organ; *a.mx.f.*, anterior maxillary foramen; *b.o.*, basi-occipital; *b.o.c.*, basi-occipital cartilage; *b.s.*, basisphenoid; *c.m.*, cartilaginous meniscus at the end of the basipterygoid process of the basisphenoid; *ex.o.*, ex-occipital; *ex.st.*, extra-stapes (proportionately much enlarged); *int.c.*, intercalary cartilage; *i.p.*, incisura piriformis (interpterygoid fissure); *i.s.*, ventral border of the interorbital septum: *j.*, jugal; *j.f.c.f.*, combined jugular and condylar foramen: *mx.*, maxilla; *o.c.*, occipital condyle; *o.s.*, orbitosphenoid; *pal.*, palatine; *pmx.*, premaxilla; *p.n.*, position of the posterior nares; *p.o.*, postorbital; *p.s.*, parasphenoid; *p.s.s.*, septum (planum) supra-septale; *pty.*, pterygoid; *q.*, quadrate; *q.pty.*, quadrate process of the pterygoid; *s.o.f.*, sub-orbital fossa; *sq.*, posterior end of squamosal; *s.t.*, posterior end of supra-temporal; *st.*, stapes; *tr.*, transverse; *t.s.o.*, tuberculum spheno-occipitale; *vl.fr.*, ventro-lateral process of the frontal; *vo.*, vomer; *vo.a.*, vomerine aperture; *vo.m.p.*, vomero-maxillary process of the premaxilla; *v.pmx.f.*, ventral premaxillary foramen. Cartilages are shown with uniformly thick dots.

forming the base of the triangle, is crescentic in outline, being convex from side to side, and fits against the basisphenoid in front and the pro-otic on each side ; the two lateral borders forming the two sides of the triangle are concave in outline and fit against the ex-occipital of each side ; the posterior end of the bone corresponding to the apex of the triangle forms the median piece of the occipital condyle and also a very small part of the ventral boundary of the foramen magnum. The dorsal surface of the basi-occipital is depressed to form an oval area for the accommodation of the ventral surface of the medulla oblongata ; in fact, the bone in this oval area is thin and appears translucent against transmitted light, the remaining portion of the bone being thick and opaque. On each of the two antero-lateral borders of the basi-occipital, between it and the pro-otic, there is a kidney-shaped cartilaginous tuberosity wedged in between these bones on each side : this is called the *tuberculum spheno-occipitale* (figs. 1 and 13). On this are inserted, on each side, strong tendons of two muscles, (1) the *musculus longus colli* and (2) the *musculus transversalis cervicis*[1].

The paired *ex-occipitals* (figs. 1, 2 and 3) of the adult are irregularly shaped bones, each formed by a fusion of the ex-occipital proper with the opisthotic of its own side ; each is, therefore, a compound bone, and, since it forms not only the side-wall of the cranial cavity but also a part of the auditory capsule and a prominent lateral process, the *paroccipital process*, it has been named by different workers as *pleuro-occipital, lateral occipital* or *oto-occipital.*

The ex-occipital proper is the small triangular plate lying ventro-laterally on each side of the basi-occipital (fig. 1), while the remaining larger part of the bone lying on the dorsal and outer side almost at a right angle to the ex-occipital proper represents the opisthotic. The ex-occipital part of the bone fits all along its inner border against the basi-occipital, while the opisthotic part fits anteriorly and externally against the pro-otic and dorsally against the posterior half of the supra-occipital. The ventral surface of the ex-occipital is depressed and forms the place of insertion of the *musculus rectus capitis inferior.* This muscle lies immediately above the *musculus longus colli* and arises from the hypophysial processes of the first four cervical vertebrae. The muscle-fibres are inserted directly on the ex-occipital without the formation of a tendon.

The boundary between the ex-occipital and opisthotic parts of the bone is clearly indicated on the *inner surface of the cranium* (seen in a

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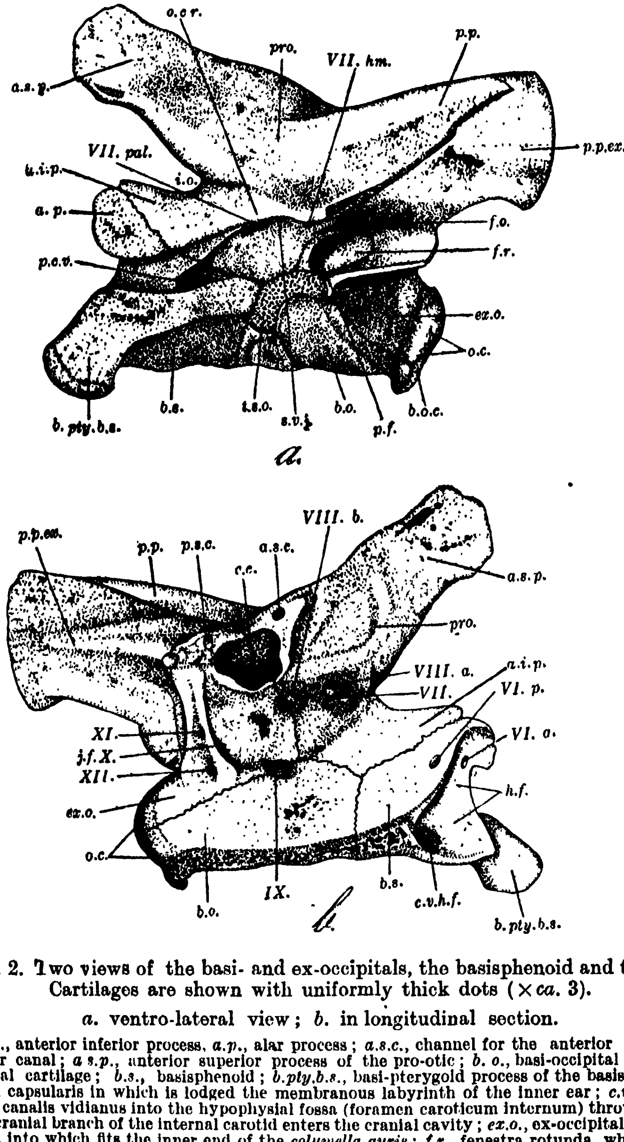
[1] As the nomenclature of these two muscles is uncertain, I am giving here their origin, extent and insertion. The *musculus longus colli* of each side is an elongated elliptical muscle inserted by a distinct tendon on the inner part of the tuberculum spheno-occipitale. The bodies of the two muscles lie closely pressed together in the neck, one on each side of the mid-ventral line, immediately dorsal to the oesophagus and ventral to the cervical vertebrae. Their fibres originate from the hypopophyses of the first *seven* vertebrae. The *musculus transversalis cervicis* is inserted by a distinct tendon on the outer part of the tuberculum, but this tendon continues on its outer side into an aponeurosis inserted on the entire outer border of the ventral part of the ex-occipital. The body of the muscle itself consists of two parts : (1) a short anterior part which originates from the second vertebra and a part of the third, and (2) a long posterior part which originates from a part of the third and the fourth and fifth vertebrae. The muscle is attached to the outer surface of each neural arch along the line joining the pre- and post-zygapophyses.

longitudinal section) by a large crescentic slit-like aperture, the *jugular foramen* or *foramen lacerum posterius* (fig. 2 *b*), which lies between



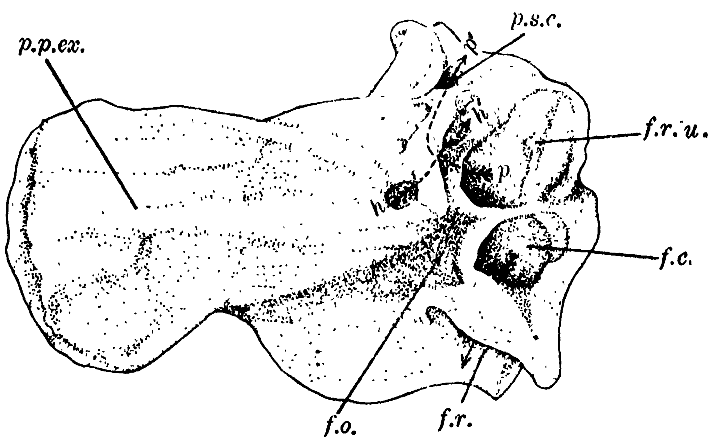
TEXT-FIG. 2. Two views of the basi- and ex-occipitals, the basisphenoid and the pro-otic. Cartilages are shown with uniformly thick dots ($\times$ *ca.* 3).

a. ventro-lateral view; *b.* in longitudinal section.

a.i.p., anterior inferior process, *a.p.*, alar process; *a.s.c.*, channel for the anterior vertical semi-circular canal; *a s.p.*, anterior superior process of the pro-otic; *b. o.*, basi-occipital; *b.o.c.*, basi-occipital cartilage; *b.s.*, basisphenoid; *b.pty.b.s.*, basi-pterygoid process of the basisphenoid; *c.c.*, cavum capsularis in which is lodged the membranous labyrinth of the inner ear; *c.v.h.f.*, opening of the canalis vidianus into the hypophysial fossa (foramen caroticum internum) through which the intra-cranial branch of the internal carotid enters the cranial cavity; *ex.o.*, ex-occipital; *f.o.*, fenestra ovalis, into which fits the inner end of the *columella auris*; *f.r.*, fenestra rotunda, which is covered over in life by the *membrana tympani scundaria* and through which the glossopharyngeal nerve leaves the skull; *h.f.*, hypophysial fossa; *i.o.*, incisura otosphenoidea for the Vth nerve; *j.f.x.*, jugular foramen for the exit of the jugular vein and the tenth cranial nerve; *o.c.*, occipital condyle; *o.cr.*, otosphenoidal crest; *p.c.v.*, posterior opening of the *canalis vidianus* through which the palatine branch of the facial nerve and the sympathetic and the internal carotid artery enter the basisphenoid bone; *p.f.*, perilymphatic foramen; *p.p.*, posterior process of the pro-otic; *p.p.ex.*, paroccipital process of the ex-occipital; *pro.*, pro-otic; *p.s.c.*, channel for the posterior vertical semi-circular canal; *s.v.j.*, sulcus venae jugularis; *t.s.o.*, tuberculum spheno-occipitale; *VI.a.*, anterior foramen for the exit of the sixth cranial nerve out of the basisphenoid; *VI.p.*, posterior foramen through which the VIth cranial nerve enters the basisphenoid bone; *VII.*, facial foramen through which the VIIth nerve leaves the cranial cavity; *VII.hm.*, posterior facial foramen for the exit of the hymomandibular division of the VIIth nerve; *VII.pal.*, anterior facial foramen through which the palatine, branch of the VIIth nerve leaves the skull; *VIII.a.*, foramen acusticum anterius; *VIII.b.*, foramen acusticum posterius; *IX.*, foramen perilymphaticus or glossopharyngeal foramen; *XI.*, foramen for the exit of the spinal accessory nerve; *XII.*, foramen for the exit of the hypoglossal nerve.

the two parts of the bone in such a manner that the anterior wall of the foramen is formed by the opisthotic and its posterior wall by the ex-occipital. The jugular foramen transmits the vagus nerve (X), the *vena cerebralis posterior branch* of the internal jugular vein and the *occipital branch* of the occipito-vertebral artery. Immediately behind the jugular foramen lie two small rounded foramina (fig. 2 *b*), one above the other, on the inner surface of each ex-occipital: the lower of these two transmits the *hypoglossal nerve* (XII), while the upper lets through the *spinal accessory nerve* (XI). On piercing the cranial wall internally, these two foramina open into the large jugular foramen, so that on the outer surface of the cranium there is a single large oval foramen lying just outside the occipital condyle at the root of each paroccipital process. This is, therefore, the combined *foramen lacerum posterius* (*jugular foramen*) + the *condylar* (*hypoglossal*) *foramen* of the mammalian skull and also that of *Sphenodon* and lets through the internal jugular vein (*vena cerebralis posterior branch*) and the Xth, XIth and XIIth cranial nerves and lets in the *occipital branch* of the occipito-vertebral artery (figs. 1, 2 and 13).

The opisthotic part of the bone forms (1) the posterior part of the auditory capsule, and (2) a stout horizontal process, the *paroccipital process,* directed outwards and slightly backwards. This process on each side supports the supra-temporal above and the quadrate below. On the dorsal surface of the opisthotic part, at the root of the paroccipital process, there is a small foramen (figs. 2 *b*, 3 and 10) leading above and below into the passage for the *posterior vertical semi-circular canal* of the internal ear; while on the anterior vertical surface of the paroccipital process, at its root, lies the foramen leading behind and



TEXT-FIG. 3. Fronto-lateral view of the ex-occipital (×*ca.* 7).

f.c., fenestra cochleae leading below into *f.r.*, the fenestra rotunda, the passage being shown by an arrow; *f.o.*, the posterior wall of fenestra ovalis; *f.r.u.*, recessus utriculi; *h-h'*, arrow passing through the channel for the horizontal semi-circular canal; *p-p'*, arrow passing through the channel for the posterior semi-circular canal; *p.p.ex.*, paroccipital process of the ex-occipital; *p.s.c.*, opening for the posterior semi-circular canal.

in front into the passage for the *horizontal semi-circular canal.* These two foramina can only be seen in the disarticulated bone (fig. 3);

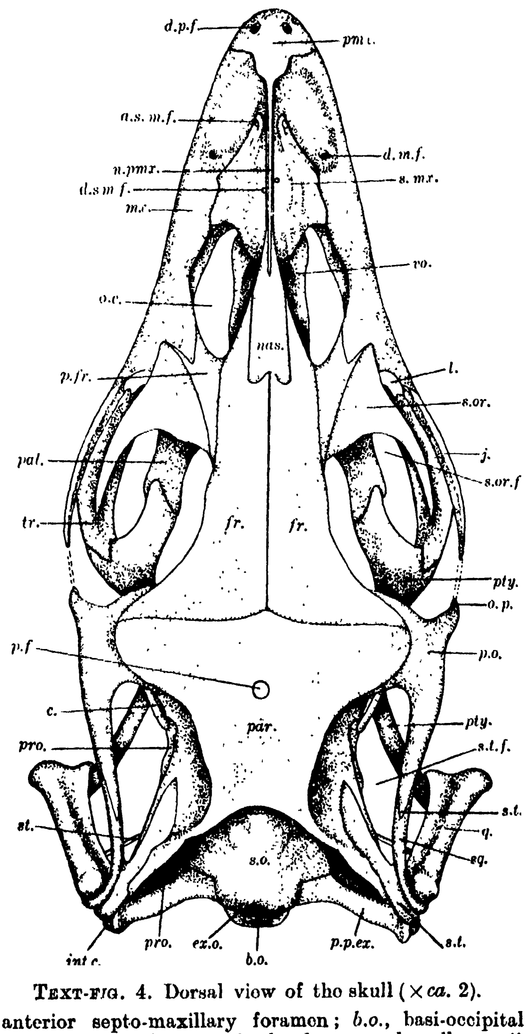
in the complete skull the first foramen is covered over by the supra-occipital and the second by the pro-otic. The anterior end of each opisthotic is excavated to form a fossa which extends upwards into the supra-occipital, and is continuous with a similar fossa on the postero-internal surface of the pro-otic, the fossae on these three bones together forming the cavity (*cavum capsularis*) of the auditory capsule (figs. 5 and 10) in which is lodged the membranous labyrinth of the internal ear. These fossae also can be seen separately only in a disarticulated skull.

The fossa of the opisthotic part of the auditory capsule presents a central recess, a large foramen on the inner and ventral side and another small one on the outer and dorsal side (fig. 3). The central recess lodges the *recessus utriculi* and the *ampulla posterior* leading into the posterior semi-circular canal; the outer and dorsal foramen leads into the passage for the horizontal semi-circular canal, while the inner and ventral foramen (*fenestra cochleae* or *perilymphatica*) provides for the passage of the *aqueductus perilymphaticus* into the *recessus scalae tympani* of the *fenestra rotunda*[1]. The fenestra rotunda (fig. 2 *a*), is a large, more or less elliptical, opening with an arched roof, lying on the outer lateral surface of the skull, between the outer convex border of the ex-occipital below and the fenestra ovalis above. It is closed in life by a thick membrane, the *membrana tympani secundaria*, which is really the outer wall of the *saccus perilymphaticus*, lying in a short space within the fenestra rotunda. This space is called the *recussus scalae tympani* and opens above through the *fenestra cochleae* into the *cavum vestibulare* (inner middle region of *cavum capsularis*) and inwards through the *aqueductus perilymphaticus* passing through the *perilymphatic foramen* into the subarachnoid spaces beneath the brain in the cranial cavity. The *glossopharyngeal nerve* leaves the cranial cavity through the *foramen perilymphaticus* (fig. 2*b*), runs along the posterior wall of the *recessus scalae tympani* imbedded in the wall of the perilymphatic membrane and emerges out of the *fenestra rotunda* into the cavity of the middle ear. The greater part of the *fenestra rotunda* is formed by the ex-occipital, which forms a process resembling an arched bridge, only the antero-ventral end being formed by the tuberculum spheno-occipitale (fig. 2 *a*). Similarly, the posterior part of the *fenestra ovalis*, lying immediately above the *fenestra rotunda*, is formed by the opisthotic, being closed anteriorly by the pro-otic. It should be noted that both the fenestra ovalis and fenestra rotunda lie at the bottom of a shallow pit bounded ventrally by the free lateral border of the ex-occipital and dorsally by the pro-otic and the paroccipital process: this pit is the inner part of the middle ear, which has a wide communication with the pharynx below, and across which runs the *columella auris* from the fenestra ovalis to the tympanic membrane on the outside (figs. 1, 6 and 13).

The median *supra-occipital* (figs. 3, 4, 5 and 6) forms the roof of the occipital segment and also that of the auditory capsule on each side. Dorsally, it lies at a lower level behind the parietals and slopes in an antero-posterior direction as well as laterally on each side. Looked

[1] In *Sphenodon*, as in the Chelonia, Ophidia and *Anser* (*Aves*), there is no fenestra rotunda and no membrana tympani secundaria either.

at from the dorsal surface, it is more or less hexagonal in outline with a notch on its posterior border. The anterior crescentic border of the bone rests against the united parietals in front but there is no close-fitting sutural union between the two bones, the joint being formed of

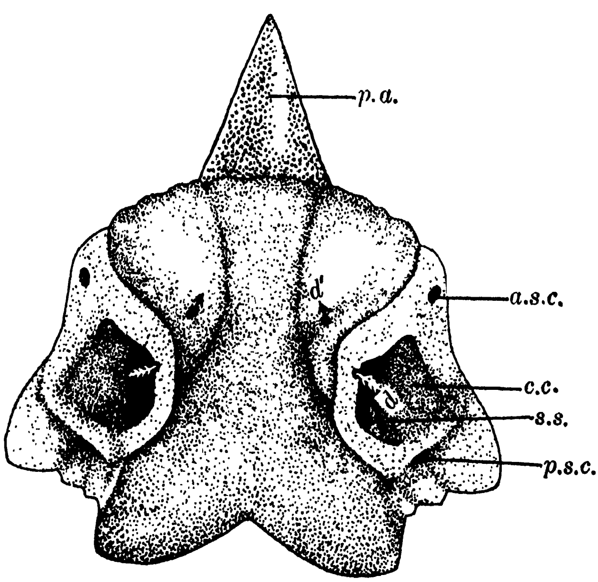


TEXT-FIG. 4. Dorsal view of the skull (× *ca.* 2).

a.s.m.f., anterior septo-maxillary foramen; *b.o.*, basi-occipital with the basi-occipital cartilage covering its posterior border; *c.*, columella cranii or epipterygoid; *d.m.f.*, dorsal maxillary foramen; *d.p.f.*, dorsal pre-maxillary foramen; *d.sm.f.*, dorsal septo-maxillary foramen; *ex.o.* ex-occipital; *fr.*, frontal; *int.c.*, intercalary cartilage; *j.*, jugal; *l.*, lacrymal; *mx.*, maxilla; *nas.*, nasal; *n.pmx.*, nasal process of the premaxilla; *o.c.*, place for the cartilaginous olfactory capsule; *o.p.*, orbital process of the post-orbital; *pal.*, palatine; *par.*, parietal; *p.f.*, parietal foramen; *p.fr.*, pre-frontal; *pmx.*, premaxilla; *p.o.*, post-orbital; *p.p.ex.*, paroccipital process of the ex-occipital; *pro.*, pro-otic; *pty.*, pterygoid; *q.*, quadrate; *s.mx.*, septo-maxillary; *s.o.*, supra-occipital; *s.or.*, supra-orbital; *s.or.f.*, supra-orbital fossa; *sq.*, squamosal; *s.t.*, supra-temporal; *s.t.a.*, supra-temporal arcade; *s.t.f.*, supra-temporal fossa; *st.*, stapes or columella auris; *tr.*, transverse; *vo.*, vomer.

fibrous tissue and cartilage, the two bones being movable on each other vertically within a limited range. In the middle line, there is a cartilaginous piece (fig. 5) perfectly cone-shaped in appearance, which projects

from the anterior border of the supra-occipital and fits closely into a deep funnel-shaped depression (*parietal fossa*) into the posterior border of the parietal in the median line (fig. 5). Bradley (**2**, p. 482) regards this cone-shaped cartilage as corresponding to the *processus ascendens tecti synotici* of the cartilaginous cranium. There is thus a " peg and socket " joint between the supra-occipital and the united parietals which would obviously allow only a limited range of movement between these two bones. This joint is an important feature of the Lacertilian skull and forms an essential factor in the *kinetism*[1] of the skull (*vide infra*). The two antero-lateral borders of the supra-occipital fit against the pro-otics on each side, the postero-lateral borders against the ex-occipitals, while the posterior border with the notch is free and forms the roof of the foramen magnum (fig. 6). Along its mid-dorsal line runs an inconspicuous *occipital ridge* or *crest* and the bone slopes down on each side of this crest to meet the ex-occipital behind and the pro-otic in front. The disarticulated supra-occipital resembles in shape the neural arch of a vertebra with thick lateral walls; its ventral aspect (fig. 5) gives the appearance of a deep gutter with thick and expanded but hollowed walls. Each of these thick walls forms the roof of the auditory capsule and is hollowed out into a central fossa which lodges the dorsal portion of the membranous labyrinth. Deep down on the inner wall of the fossa, there is a rounded aperture leading into a narrow tube which lodges the *sinus*



TEXT-FIG. 5. Ventral view of the supra-occipital (× *ca.* 6).

a.s.c., channel for the anterior semi-circular canal; *c.c.*, the dorsal part of the cavum capsularis; *d-d'*, arrow passing through the aquaductus endolymphaticus which lodges the ductus endolymphaticus; *p.a.*, processus ascendens (cartilaginous); *p.s.c.*, channel for the posterior semi-circular canal; *s.s.*, channel for the sinus superior leading into the channel for the anterior semi-circular canal in front and the channel for the posterior semi-circular canal behind.

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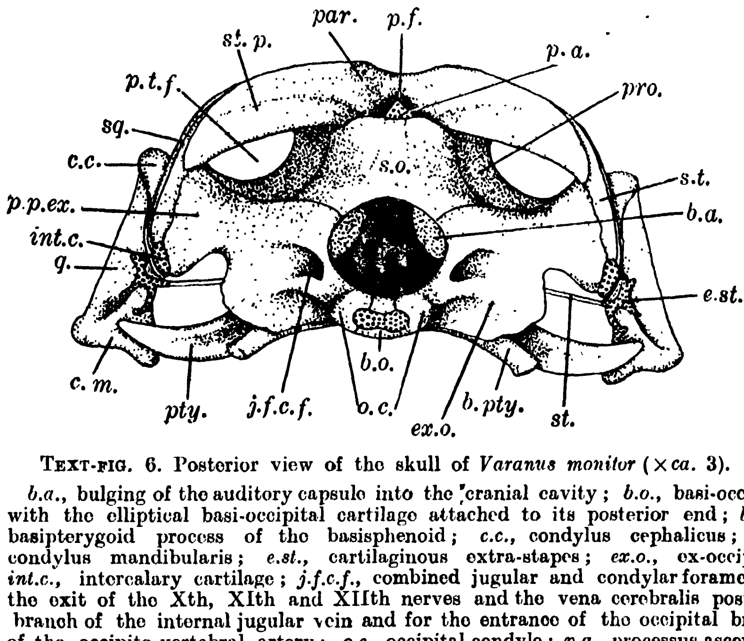
[1] The fronto-parietal region of the skull is movable upon the occipito-sphenoidal part.

superior of the membranous labyrinth; this tube leads into minute hair-like tunnels both anteriorly and posteriorly which can be seen as extremely minute apertures on the outer wall, one lying anteriorly and the other posteriorly to the fossa; these tunnels accommodate the upper parts of the *anterior* and *posterior vertical semi-circular canals* (fig. 5). A third hair-like tunnel pierces the inner wall of the fossa a little above and anterior to the aperture for the sinus superior; it leads into the cranial cavity by a minute aperture (*aqueductus vestibuli*) lying on the antero-lateral surface of the inner wall of the supra-occipital as seen from the ventral side (fig. 5); this tunnel lodges the *ductus endolymphaticus*, which opens into the cranial cavity.



TEXT-FIG. 6. Posterior view of the skull of *Varanus monitor* (×*ca.* 3).

b.a., bulging of the auditory capsule into the cranial cavity; *b.o.*, basi-occipital with the elliptical basi-occipital cartilage attached to its posterior end; *b.pty.*, basipterygoid process of the basisphenoid; *c.c.*, condylus cephalicus; *c.m.*, condylus mandibularis; *e.st.*, cartilaginous extra-stapes; *ex.o.*, ex-occipital; *int.c.*, intercalary cartilage; *j.f.c.f.*, combined jugular and condylar foramen for the exit of the Xth, XIth and XIIth nerves and the vena cerebralis posterior branch of the internal jugular vein and for the entrance of the occipital branch of the occipito-vertebral artery; *o.c.*, occipital condyle; *p.a.*, processus ascendens cartilage fitting into the parietal fossa; *par.*, parietal; *p.f.*, parietal fossa; *p.p.ex.*, paroccipital process of the ex-occipital; *pro.*, pro-otic; *p.t.f.*, post-temporal fossa; *pty.*, pterygoid; *q.*, quadrate; *s.o.*, supra-occipital; *sq.*, squamosal; *s.t.*, supra-temporal; *st.*, stapes; *st.p.* supra-temporal process of the parietal.

The supra-occipital forms the roof of the bun-shaped cerebellum disposed in an obliquely dorso-ventral direction and the medulla oblongata (hind-brain). The anterior border and the dorsal surface of the supra-occipital form the place of insertion for the occipito-vertebral muscles (*rectus capitis, obliquus capitis* and *spinalis capitis muscles*). These muscles form a thick pad covering the supra-occipital in such a way that, on removal of the integument, the occipital segment appears on the same level with the parietal.

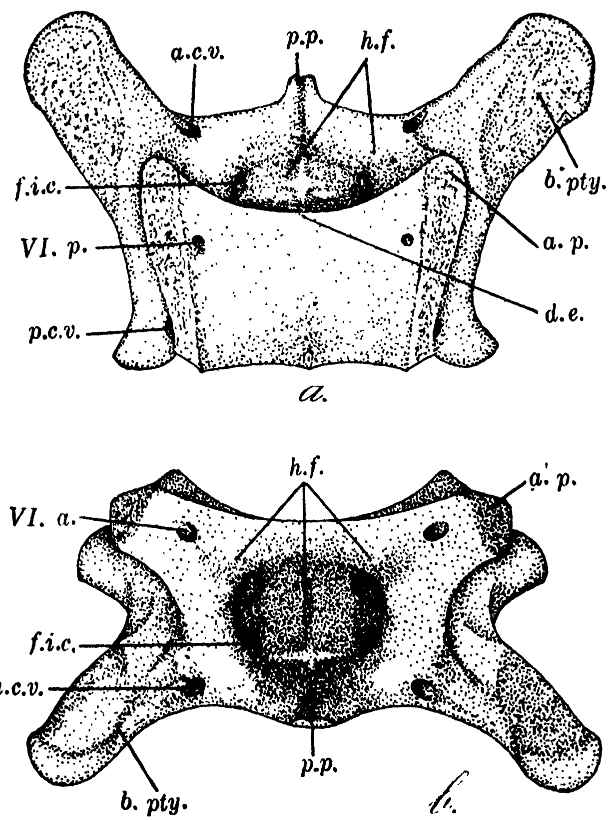
In *Sphenodon*, the external jugular foramen transmits the IXth Xth and XIth nerves and the vena cerebralis posterior branch of the internal jugular, while there is a separate foramen for the XIIth nerve. In *Lacerta*, there are two separate foramina for the XIIth nerve and another for the Xth. The IXth nerve also comes out separately and not from the *fenestra rotunda* as it does in *Varanus*.

In *Lacerta* (**9**, p. 9), the *processus ascendens* of the supra-occipital is bony and is only tipped with cartilage, but in *Varanus* the process is wholly cartilaginous and fits into the hinder and not on the under surface of the parietal.

(b) *The Parietal Region.*

The *parietal region* consists of the united parietals above and the median basisphenoid below. There are no alisphenoids, the side-walls of the cranium in this region being formed by the pro-otics behind and thick membranous walls in front. The basisphenoid is a chondrocranial ossification but the parietals are dermal bones.

The *basisphenoid* (figs. 1 and 7) is more or less quadrangular in shape and lies immediately in front of the basi-occipital, forming the floor of the cranial cavity beneath the mid-brain and a part of the hind-



TEXT-FIG. 7. Two views of the basisphenoid (× *ca.* 6)
a. dorsal; *b.* anterior.

a.c.v., anterior opening of canalis vidianus; *a.p.*, alar process; *b.pty.*, basipterygoid process; *d.e.*, dorsum ephippi; *f.i.c.*, foramen caroticum intercum; *h.f.*, hypophgsial fossa; *p.c.v.*, posterior opening of canalis vidianus; *p.p.*, parasphenoid process; *VI.a.*, anterior foramen for the abducens nerve; *VI.p.*, posterior foramen for the abducens nerve.

brain. Its posterior border is straight and single, fitting closely and immovably against the basi-occipital, but the anterior border is double,

there being a *dorsal anterior border* (*dorsum ephippi*) and a *ventral anterior border* formed as a result of the presence at the anterior end of a large and deep depression called the *hypophysial fossa* (*sella turcica*), which lodges the *recessus infundibularis* and the *hypophysis* of the diencephalon. The dorsal anterior border is concave and is produced laterally on each side into a very short conical process (fig. 7) corresponding to the *alar process* in *Sphenodon*. The ventral anterior border gives off a short and stumpy median bifid process with which the parasphenoid articulates in front; this median process is therefore called the *parasphenoid process* (*processes trabeculae inferiores* of Siebenrock). On each side of this process, the bone is produced antero-laterally into a thick stout process, the *basipterygoid process*[1], which is expanded at its extremity and articulates with the pterygoid, there being a cartilaginous meniscus (figs. 1 and 13) at the point of articulation. It should be noted that this articulation is movable like that between the supra-occipital and the parietal and forms another essential factor in the kinetism of the skull. Just as there are two anterior borders, similarly there are two lateral borders on each side, a *dorsal lateral border* and a *ventral lateral border* separated by a longitudinal groove (*sulcus venae jugalaris*) between the two; the dorsal border articulates all along its length with the pro-otic, while the ventral border is free.

The dorsal surface of the basisphenoid is concave from side to side and is higher in front than behind; the concavity of the two bones (the basi-occipital and the basisphenoid) together forms a shallow depression into which fits the ventral convex surface of the brain behind the pituitary body. In the anterior third of the dorsal surface lie two small foramina (fig. 7*a*), one on each side, for the exit of the VIth (*abducens*) *nerve*[2]. This nerve perforates the bone at the base of each alar process, runs through a very short canal and comes out into the dorsal part of the hypophysial fossa (fig. 7*b*), wherefrom it runs outwards to innervate the external rectus muscle of the eye. The base of the basipterygoid process of each side is tunnelled through by the *canalis vidianus*[3] (fig. 7*a*), through which pass the *palatine branch of the internal carotid artery* and the *palatine branch of the facial nerve*. These two structures run close together side by side along the lateral wall of the basisphenoid in the groove between its dorsal and ventro-lateral borders and then pass together through the canalis vidianus and even on coming out run close together on the palate. The posterior opening of the canalis vidianus lies on the lateral wall of the basisphenoid just in front of its posterior end; the anterior opening of the canal, however, lies at the base of the basipterygoid process, on each side, on the outer side of the median parasphenoid process. About the middle of its course, the *canalis vidianus* passes through the extreme lateral boundary of the

[1] The basipterygoid process of the basisphenoid represents an ossification of a part of the greatly reduced palato-quadrate cartilage (**5**, p. 428).

[2] Siebenrock (**9**, pp. 11 and 12) mentions this foramen as *foramen internum* in *Lacerta* and says that it transmits a branch of the internal carotid. According to his description, the position of the *foramen internum* is the same as that of the foramen for the VIth nerve in *Varanus*. I think Siebenrock mistook the nerve for a branch of the internal carotid; at any rate, his statement on this point needs confirmation.

[3] The palatine branch of the facial nerve, as it joins the sympathetic branch from the IXth is called the *vidian nerve* (**5**, p. 271).

hypophysial fossa. The hypophysial fossa itself is a funnel-like pit, the base of which extends laterally on each side and communicates through an aperture with the canalis vidianus. Through this aperture (foramen caroticum internum, figs. 3, 8, 9 and 11), the cranial branch of the internal carotid enters the sella turcica from the canalis vidianus and becomes completely intra-cranial; it then runs laterally to the hypophysis and mounts upwards to supply the latero-ventral wall of the brain.

The united *parietal* (fig. 4) forms a more or less quadrangular bony plate, narrow in the middle but expanded both anteriorly and posteriorly. It articulates in front with the paired frontals through a more or less straight transverse suture, but is produced behind into two long, stout and laterally compressed processes, the *supra-temporal processes* —*processus parietales* of Siebenrock—(fig. 6), which diverge and run outwards and backwards to articulate behind with the supra-temporal on each side through an obliquely running suture. Laterally, between the supra-occipital and the pro-otic on one side and the parietal on the other, there is always a small area which is unossified and in a dry skull looks like a triangular fissure. It is covered in life with a thick fibrous membrane and provides a loose movable connection between the parietal and the pro-otic, so that the whole of the occipital segment, the basisphenoid and the pro-otic move as one piece on the parietal (Kinetism).

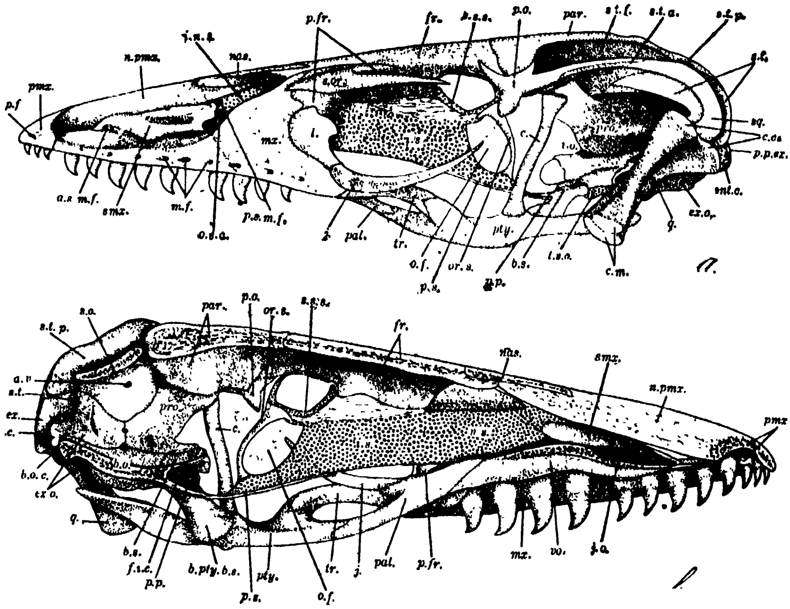
Each of the two concave lateral borders of the parietal is bevelled off all along its length to form a narrow ledge (fig. 4) slanting outwards; these bevelled ledges serve chiefly for the attachment of the adductor mandibulae medius muscles. The *parietal process* (*anterior superior process*) of the *pro-otic* articulates movably with each of these bevelled borders about the middle of its length.

The dorsal surface of the united parietal is evenly flat like that of the frontals, but the ventral surface is slightly concave from side to side, forming a shallow depression into which fits the dorsal surface of the fore-brain and the mid-brain. In the anterior half of the bone, right in the median line, lies the oval *parietal foramen*, into which fits the parietal organ. Between the roots of the supra-temporal processes, the posterior border of the parietal is excavated in the median line to form a deep funnel-like pit, the *fossa parietalis* (fig. 6), which in the entire skull is hidden by the anterior border of the supra-occipital. Into the fossa parietalis is inserted the cone-shaped cartilaginous projection[1] from the anterior border of the supra-occipital, forming a "peg and socket" joint (p. 142).

The basisphenoid of *Varanus* presents important differences from that of *Sphenodon*. The alar processes are very short and there is no median dorsal process of the *dorsum ephippi*. Further, the anterior openings of the canalis vidianus are paired and not median and common as in *Sphenodon*, and the canalis vidianus transmits both the palatine artery and nerve and not the palatine artery alone as it does in

[1] The processus ascendens tecti synotici cartilage.

Sphenodon. The parietals are united and not separate as in *Sphenodon*, while the inter-parietal crest is absent.



Text-fig. 8. Two views of the skull : *a.*, Lateral left side ; *b.* Median longitudinal section (× *ca.* $1\frac{1}{2}$).

a.s.m.f., anterior septo-maxillary foramen ; *a.v.*, aqueductus vestibuli for the ductus endolymphaticus of the internal ear ; *b.o.*, basi-occipital ; *b.o.c.*, basi-occipital cartilage : *b.pty.b.s.*, basipterygoid process of the basisphenoid ; *b.s.*, basisphenoid ; *c.*, columella cranii (epipterygoid) ; *c.c.*, condylus cephalicus of the quadrate ; *c.m.*, condylus mandibularis of the quadrate ; *d.p.f.*, dorsal pre-maxillary foramen ; *ex.o.*, ex-occipital ; *f.i.c.*, foramen caroticum internum ; *fr.*, frontal ; *i.n.s.*, internasal septum ; *int.c.*, intercalary cartilage ; *i.o.*, incisura otosphenoidea ; *i.s.*, inter-orbital septum ; *j.*, jugal ; *j.o.*, cavity for the Jacobson's organ ; *l.*, lacrymal ; *m.f.*, maxillary foramina ; *mx.*, maxilla ; *nas.*, nasal ; *n.pmx.*, nasal process of the pre-maxilla ; *n.s.*, nasal septum ; *o.c.*, occipital condyle ; *o.f.*, optic fenestra ; *or.s.*, orbitosphenoid ; *pal.*, palatine ; *par.*, parietal ; *p.fr.*, prefrontal ; *pmx.*, premaxilla ; *p.o.*, postorbital ; *p.p.*, parasphenoid process (*processus trabeculae inferiores*) of the basisphenoid ; *p.p.ex.*, paroccipital process of the exoccipital ; *pro.*, pro-otic ; *p.s.*, parasphenoid ; *p.s.m.f.*, posterior septo-maxillary foramen ; *pty.*, pterygoid ; *q.*, quadrate ; *smx.*, septo-maxillary ; *s.or.*, supra-orbital ; *sq.*, squamosal ; *s.s.s.*, septum (planum) supra-septale ; *s.t.*, supra-temporal ; *s.t.a.*, supra-temporal arcade ; *s.t.f.*, supra-temporal fossa ; *s.t.p.*, supra-temporal process of the parietal ; *tr.*, transverse ; *t.s.o.*, tuberculum spheno-occipitale ; *vo.*, vomer. The foramina on the hinder part of the skull are labelled in fig. 2.

(c) *The Frontal Region.*

The *frontal region* consists of the paired frontals above, the median narrow parasphenoid below and a pair of minute orbito-sphenoids surrounding the large optic chiasma. Of these five bones, only the two orbito-sphenoids are chondrocranial ossifications, the parasphenoid and the two frontals being dermal bones.

Besides these bones, there are several cartilaginous and membranous tracts which complete the wall of the reduced cranial cavity of this region. The brain-cavity is confined here to the dorsal part of the skull and lodges only the anterior part of the cerebral hemispheres and the olfactory stalks, the remaining greater part of the brain having been

pushed back behind the large eyes into the parietal and occipital regions. The brain is obliquely placed: the olfactory stalks are lodged in the narrow tubular cavity formed by the ventro-lateral extensions of the frontals, the cerebral hemispheres are covered by the frontals above and are supported by cartilage and thick fibrous membrane below, while the optic chiasma is surrounded by the minute orbitosphenoid bones. The *inter-orbital septum* extends forwards from the median parasphenoid process of the basisphenoid, and lies below the narrow cranial cavity between the two large orbits, continuing forwards into the olfactory chamber as the *inter-nasal septum* (fig. 8*b*). As the cranial cavity is very much reduced between the large eyes and is largely replaced by the inter-orbital septum, the skull is almost completely *tropibasic*.

The *parasphenoid* (figs. 1 and 8*b*) is a long narrow bone flattened dorsoventrally and resembling in shape the blade of a bayonet. It underlies the ventral border of the inter-orbital septum in the mid-ventral line just in front of the basisphenoid, articulating behind with the median parasphenoid process of the basisphenoid and terminating in front at a point about half the length of the inter-orbital septum (fig. 8*b*). Posteriorly, the parasphenoid protects the infundibulum of the diencephalon and even forms part of the hypophysial fossa, while along the greater part of its length it forms the ventral support of the posterior half of the inter-orbital septum. In a freshly prepared skull, the parasphenoid is more or less horizontal in position, being only slightly bent upwards anteriorly; but in a dried skull, as the inter-orbital septum shrivels up, the parasphenoid gets bent upwards, but its anterior end never reaches the frontal as is shown by Reynolds (7) in his diagrams.

The parasphenoid of *Varanus* is very much reduced and corresponds only to the *rostrum parasphenoidei* (*processus cultriformis*) of *Sphenodon*, the main body of the parasphenoid corresponding to the hinder wing-like processes, the middle shield and the transverse processes of the parasphenoid of *Sphenodon* being absent.

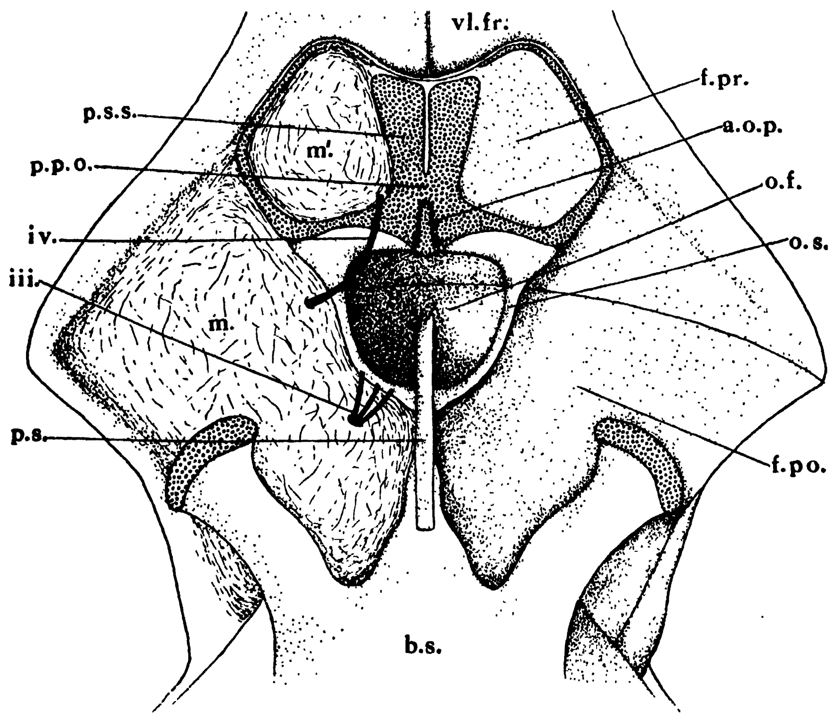
The paired *frontals* (fig. 4) are elongated bones, narrow in front but broad behind. They articulate with each other through a long and straight median suture and with the parietals behind through a more or less straight transverse suture. Anteriorly each frontal presents a shallow concavity and a cleft, into which is wedged in one of the two posterior processes of the united nasals, while along the anterior half of its outer lateral border, there is a triangular depression for articulation with the pre-frontal of its own side. Dorsally, the frontals are evenly flat and lie at the same level with the parietals, but laterally each is inflected downwards and inwards to form a latero-ventral process (fig. 8*b*), which meets the corresponding process of the other side, enclosing a more or less complete bony canal (*canalis olfactorius*[1]), in which are lodged the elongated olfactory stalks. Ventrally these inflected processes enclose between them the dorsal membranous border of the inter-orbital septum.

The ventro-lateral walls of the cranial cavity (fig. 9) enclosing the fore-brain are formed partly of calcified and hyaline cartilage, partly

[1] In *Lacerta*, the canalis olfactorius is mainly membranous.

of a thick fibrous membrane and partly by the paired *orbitosphenoid* bones. The cartilaginous portion is represented by the *planum* (*septum*) *supra-septale* or *pila preoptica* and its lateral extensions. The planum supra-septale (figs. 1 and 9) rests anteriorly against the ventral part of the posterior border of the canalis olfactorius and is divided into two longitudinal strips along the greater part of its length by the insertion of the dorsal border of the inter-orbital septum. The posterior part of the cartilage is undivided; it forms the anterior boundary of the *optic fenestra* and gives off an obliquely directed median ventral process, the *anterior optic process* (fig. 9) and two long narrow *lateral processes* which extend upwards and reach the frontals above, and then run forwards along their postero-ventral borders (figs. 8*b* and 9).

The *orbitosphenoids*[1] (figs. 1, 8*b* and 9) are two minute, curved, and flattened bones which are connected anteriorly with the *pila*



TEXT-FIG. 9. The orbitosphenoids and the connected cartilages and membranes from the ventral side (× *ca.* 4½).

a.o.p., anterior optic process; *b.s.*, basisphenoid; *f.po.*, fenestra postoptica; *f. pr.*, fenestra preoptica; *m.*, membrane covering the fenestra postoptica; *m'.*, membrane covering the fenestra preoptica; *o.f.*, optic fenestra; *o.s.*, orbitosphenoid; *p.p.o.*, pila preoptica; *p.s.*, parasphenoid; *p.s.s.*, planum supraseptale; *vl.fr.*, ventro-lateral process of the frontal., *iii.*, the three branches of the oculomotor nerve; *iv.*, trochear nerve.

[1] Reynolds (7) shows the orbitosphenoids in a longitudinal section hanging vertically downwards from the junction of the parietal and frontal bones in *V. varius*. His diagram does not seem to be correct, as it is extremely unlikely that both could be seen in a longitudinal section. In *Varanus monitor*, they lie in a vertical position, one on each side of the middle line, between the septum supra-septale above and the posterior end of the inter-orbital septum below, as shown in fig. 8.

preoptica and posteriorly with the vestigial *pila postoptica*. The orbitosphenoids represent the reduced vestiges of the sphenethmoid ossification of some primitive extinct reptiles (**5**). Each is a slender bone, broader at its dorsal than at its ventral end and forms the antero-lateral, lateral and posterior boundary of the optic fenestra (fig. 9).

On either side of the planum supraseptale, bounded behind and laterally by its lateral extensions and in front by the frontals, there is a large oval area covered by membrane : this is the *fenestra preoptica* (fig. 12). On either side of the orbitosphenoids, there is a similar *fenestra postoptica*. The fourth nerve (pathetic) leaves the cranial cavity at the inner border of this fenestra, while the three branches of the third nerve come out a little behind the fourth (fig. 9).

The vertical *inter-orbital septum* is chiefly cartilaginous all along its length but a small dorsal part of it lying immediately below the *canalis olfactorius* of the frontals is membranous (fig. 8*b*). The optic fenestra enclosed by the two orbitosphenoids is single when looked at from the dorsal side, but as the inter-orbital septum runs vertically below it, it is seen to be divided into two when looked at from the ventral side, each of the two fenestrae providing an exit for the optic nerve of its own side. In dried skulls, the cartilages and membranes of the region and the minute orbito-sphenoid bones are lost and therefore the orbits are seen to open widely into each other.

In *Lacerta* also, the inter-orbital septum is partly membranous and partly cartilaginous. Siebenrock (**9**) applies the name inter-orbital septum only to the upper membranous part, while the lower cartilaginous part is distinguished by him as the *pre-sphenoid*.

III. The Sense-Capsules.

Of the three sense-capsules, the auditory and the olfactory are closely connected with the skull, but the optic capsule is free although it is supported and protected by a number of bones of the skull.

(a) *The Auditory Capsules.*

The *auditory capsules* are closely associated with the occipital region of the cranium and are formed on each side by the pro-otic, the opisthotic part of the ex-occipital and the supra-occipital. Each auditory capsule bulges inwards into the cranial cavity as the *auditory bulla* (fig. 6), which is easily seen on each side through the foramen magnum. All the three bones taking part in the formation of the auditory capsules are chondrocranial ossifications.

The ex-occipitals and the supra-occipital have already been described. We shall, therefore, describe the pro-otic only here.

The *pro-otic* (*otosphenoid*) is an irregularly triradiate bone on each side (figs. 2*a*, 2*b*, 8*a*, 8*b* and 10), forming the anterior and antero-ventral parts of the auditory capsule. One of its radii (the *anterior inferior process*) is flat and stumpy and articulates ventrally with the upper lateral border of the basisphenoid in front and with the tuberculum spheno-occipitale behind. Another radius (the *anterior superior*

process or the *parietal process*[1]) articulates moveably against the lateral bevelled edge of the parietal internally and against the dorsal end of the epipterygoid externally, while the third conical radius (the *posterior process*) fits against the outer surface of the paroccipital process of the ex-occipital. The central part of the bone where the three radii meet is hollowed out and fits posteriorly against the opisthotic part of the ex-occipital, completing the floor and side-walls of the auditory capsule, the roof of the capsule being formed by the supra-occipital, with the anterior half of which the pro-otic articulates dorsally. The outer surface of the dorsal part of the bone is deeply concave, while the inner surface is strongly convex.

Looked at from the side (fig. 2*a*), the anterior superior and anterior inferior processes meet at an angle and enclose between them a triangular space covered over in life with a membrane. This membrane is perforated by a large aperture through which the trigeminal nerve (Vth) leaves the cranial cavity. This triangular space corresponds to the "incisura otosphenoidea" (Siebenrock) of *Sphenodon* and *Lacerta*. The root of the anterior superior process is perforated dorsally by the *anterior vertical semi-circular canal* of the internal ear, the remaining part of which lies in the corresponding portion of the supra-occipital. The greater part of the *horizontal semi-circular canal* lies within the pro-otic in a canal-like perforation of its outer wall, the remaining part of this canal lying in the opisthotic part of the ex-occipital (fig. 10). The hollow excavation of the central part of the bone extends deep into the anterior superior process forming the anterior ampullary recess and accommodating both the *ampulla anterior* and the *ampulla horizontalis* of the membranous labyrinth (fig. 10).

On the outer surface of the bone close to its ventral border, there is a groove overhung by an elongated crest which extends forwards even on the basisphenoid ; the crest is called the *otosphenoidal crest* (fig. 2*a*), while the groove is named the *sulcus venae jugularis*. In this groove, there are two foramina : the anterior one provides for the exit of the *palatine branch*, while the posterior lets through the *hyomandibular branch* of the facial nerve. Immediately below and behind the foramen for the hyomandibular branch of the 7th nerve lies the *fenestra ovalis* (fig. 2) for the insertion of the inner end of the columella auris. The anterior and posterior facial foramina lead into a common canal within the body of the bone and open internally into the cranial cavity by a common aperture, the *facial foramen* (figs. 2*b*, and 10), lying immediately behind the "incisura otosphenoidea" and below the anterior auditory foramen. The inner surface of the pro-otic bears three foramina : the facial foramen and the anterior and posterior auditory foramina. The facial foramen provides exit for the facial (VII) nerve, while the anterior auditory foramen lets through the anterior division of the auditory nerve. The posterior auditory foramen lies at the junction of the inner wall of the pro-otic with that of the ex-occipital and lets through the posterior division of the auditory nerve.

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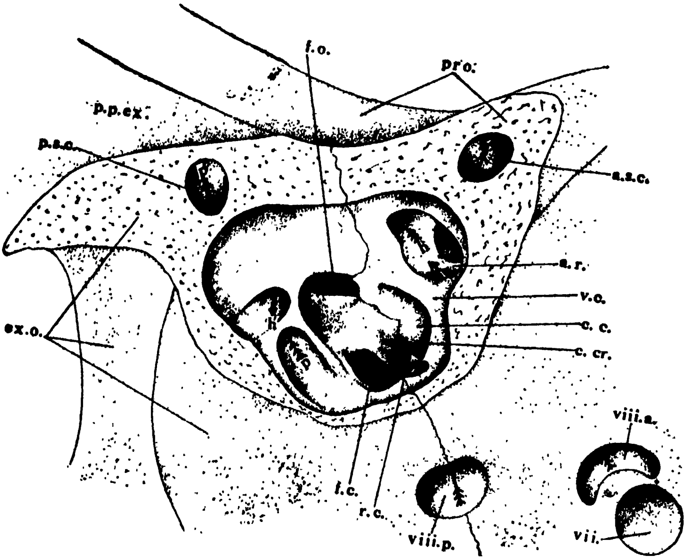
[1] *Ala otosphenoidea* of Siebenrock.

The *cavum capsularis* (fig. 10) or the cavity of the auditory capsule lodging the internal ear is a more or less spherical space lined by the



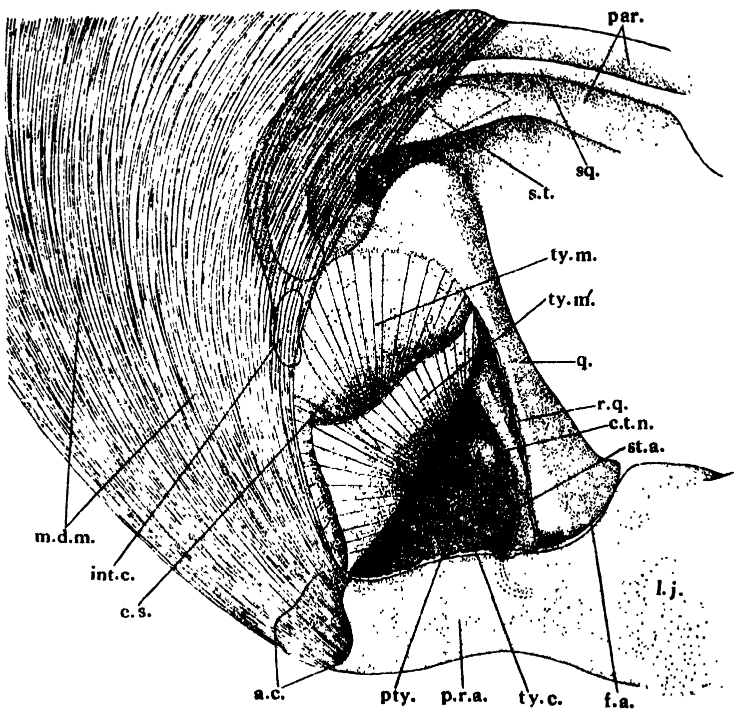
TEXT-FIG. 10. Dorsal view of the *cavum capsularis* after removal of the supra-occipital. The flat upper border with crooked lines and dots represents the place of articulation with the supra-occipital ($\times$ *ca.* 10).

a-a', arrow passing through the channel for the anterior semi-circular canal; *a.r.*, anterior ampullary recess; *a.s.c.*, opening for the anterior vertical semicircular canal; *c.c.*, cochlear cavity; *c.cr.*, cochlear crest: *ex.o.*, ex-occipital; *f.c.*, fenestra cochleae; *f.o.*, fenestra ovalis; *h.h'.*, arrow passing through the channel for the horizontal semi-circular canal; *p.p.ex.*, paroccipital process of the ex-occipital; *p.p'.*, arrow passing through the channel for the posterior vertical semi-circular canal; *pro.*, pro-otic; *r.c.*, reces sus cochlearis; *v.c.*, vestibular cavity; *vii.*, facial foramen; *viii.a.*, foramen through which the *nervus acusticus anterior* leaves the cranial cavity; the arrow represents the course of the nerve, which enters the anterior ampullary recess *a.r.* to supply the anterior part of the membranous labyrinth; *viii.p.*, foramen through which the *nervus acusticus posterior* leaves the cranial cavity; the arrow represents the course of the nerve which enters the inner wall of the vestibular cavity just above the recessus cochlearis.

perilymphatic membrane and enclosed by the ex-occipital, pro-otic and supra-occipital bones. It is divided into an upper large *vestibular cavity* containing the utriculus and the sacculus, and a lower small egg-shaped *cochlear cavity* lodging the cochlea and the legena, the two cavities being separated by a ridge called the *cochlear crest* (fig. 10). At the anterior end of the vestibular cavity lies the *anterior ampullary recess*, into which are lodged the *ampulla anterior* and *ampulla horizontalis* leading into the anterior vertical and horizontal semi-circular canals, and into which enters the *anterior auditory nerve* through a small aperture on its inner face. Along the posterior wall of the vestibular cavity lie: (1) the *posterior ampullary recess* into which is lodged the *ampulla posterior* leading into the posterior vertical semi-circular canal, and (2) the opening for the posterior end of the horizontal semi-circular canal. Along the inner wall of the vestibular cavity lies the aperture for the posterior auditory nerve. This aperture and the anterior

ampullary recess lie in the pro-otic bone, while the posterior ampullary recess and the posterior aperture for the horizontal canal lie in the ex-occipital.

The cochlear cavity presents a deep, funnel-shaped pit a long its inner wall just below the aperture for the posterior auditory nerve; this is called the *recessus cochlearis* and lodges the cochlear portion of the membranous labyrinth. Immediately behind the recessus cochlearis lies a fissure called the *fenestra cochleae* which leads below into the fenestra rotunda and through which the perilymphatic sac passes into the recessus scalae tympani. Along the outer edge of the cochlear



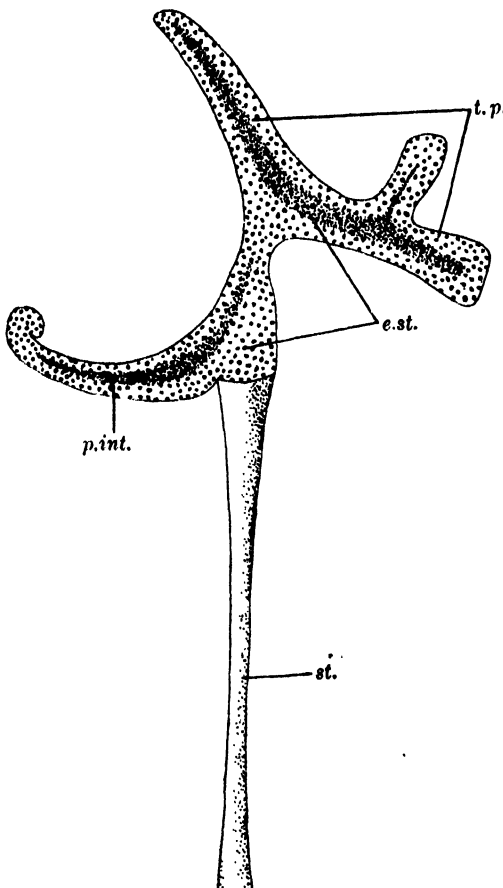
TEXT-FIG. 11. A dissection of the postero-lateral part of the head showing the tympanic membrane and its relations. The lower part of the membrane has been detached and reflected ($\times$ *ca.* 3).

a.c., position of the articular cartilage; *c.t.n.*, chorda tympani nerve; *c.s.*, position of the extra-stapes lying immediately beneath the tympanic membrane; its outline is shown in broken lines; *f.a.*, fovea articularis; *int.c.*, intercalary cartilage; *l.j.*, lower jaw; *m.d.m.*, musculus depressor mandibulae, to which is attached the posterior border of the tympanic membrane; *par.*, parietal; *p.r.a.*, processes retro-articularis, to which is attached the ventral border of the tympanic membrane; the wavy line represents the cut border of the tympanic membrane; *pty.*, posterior end of the pterygoid; *q.*, quadrate; *r.q.*, outer ridge of the quadrate to which is attached the dorsal and anterior border of the tympanic membrane; *sq.*, squamosal; *s.t.*, supra-temporal; *st.a.*, stapedial artery (arteria auricularis); *ty.c.*, tympanic cavity; *ty.m.*, tympanic membrane in position; *ty.m'.*, tympanic membrane cut and reflected.

cavity lies another fissure which opens into the fenestra ovalis and through which the inner end of the stapes fits against the perilymphatic

membrane of the internal ear. The recessus cochlearis lies in the pro-otic bone, the fenestra cochleae perforates the ex-occipital, while the fissure leading into the fenestra ovalis lies between the ex-occipital and the pro-otic. Fig. 10 represents the cavum capsularis and the associated chambers and canaliculi in relation to the different parts of the membranous labyrinth.

The *columella auris* (figs. 1 and 12) extends from the fenestra ovalis to the tympanic membrane across the cavity of the middle ear. It consists of two distinct parts: (*a*) a long proximal bony rod called the *stapes* or *columella*, with a small cartilaginous piece at its inner end embedded in the membrane closing the fenestra ovalis; the outer



TEXT-FIG. 12. The columella auris (× *ca.* 14).

e.st., extra-stapes; *p.int.*, internal or ventral process; *st.*, stapes; *t.p.*, tympanic process.

end of the stapes reaches the level of the upper end of the quadrate bone where it (the stapes) is connected with the base of the *processus*

internus of the extra-columella; and (*b*) a distal cartilaginous triradiate part called the *extra-stapes* or *extra-columella*, which consists of a thick elongated concave piece or *body* pressed obliquely against the upper half of the tympanic membrane (fig. 11) and a *processus internus* or *ventralis* (*quadrate process*) which is slightly curved and runs downwards and forwards along the posterior surface of the quadrate. A *processus dorsalis* is absent. The forked end of the body of the extra-stapes rests against the quadrate while the other pointed end reaches about the centre of the tympanic membrane (fig. 11). A strong ligament passes from the "intercalary" (a meniscus of cartilage wedged in between the quadrate and the paroccipital process of the ex-occipital ventro-internally) to the outer side of the body of the extra-stapes, between it and the tympanic membrane; another ligament from the intercalary passes directly across the anterior surface of the extra-stapes and is inserted along the anterior surface of the *processus internus* (fig. 13).

The *chorda tympani nerve* (figs. 11 and 13) branches off from the hyomandibular division of the VIIth along the posterior wall of the cavity of the middle ear, close to the upper end of the quadrate, and runs forwards and downwards along the ridge on the posterior surface of the quadrate, between it and the processus internus of the extra-columella, towards the lower end of the quadrate, where it crosses over to the outer side of the pterygo-quadrate articulation (fig. 13) and then runs downwards to enter into the foramen on the dorsal surface of the post-articular process of the mandible.

We may note here that the anterior and dorsal borders of the tympanic membrane are supported by the outer elongated ridge (tympanic crest) and the upper end of the quadrate and that the ventral border of the tympanic membrane is supported by the post-articular process of the mandible of the lower jaw, while its posterior border is supported by the *musculus depressor mandibulae* (fig. 11).

(b) *Bones in Relation with the Optic Capsules.*

The *optic capsule* proper (the eye-ball) remains free from the skull and retains its usual mobility. It is not bony by itself but is protected by a number of bones of the skull, which are described at this place as a matter of convenience.

The *supra-orbitals* (fig. 4) are a pair of triangular bones, each of which is attached by its broad base to the outer upper border of the pre-frontal of its own side, but is free along its other two sides and also at its apex. The bone is more or less flattened and strongly curved backwards, so that its inner border is strongly concave while the outer border is slightly convex. The detached bone strongly resembles a large tooth of a shark. The supra-orbital undoubtedly affords a strong protection to the antero-dorsal part of the eye-ball and forms the anterior and incomplete outer boundary of the *supra-orbital fossa*.

The paired *pre-frontals* (fig. 8*a*) are capsule-shaped bones, each with an elongated conical process, which forms a sort of handle to the capsule and articulates with the antero-lateral border of each frontal. The capsular body of the bone articulates directly with the lacrymal on the outside and with the maxilla in front, and through a small inter-

vening area of cartilage with the palatine below. The triangular supra-orbital is loosely attached to its antero-lateral border and often gets detached. The posterior surface of the pre-frontal forms the anterior wall of the orbit, while its anterior cup-shaped surface together with the lacrymal forms the hind-wall and part of the lateral wall of the olfactory chamber. The outer border of the pre-frontal with the inner border of the lacrymal encloses a large oval aperture, the *orbito-nasal canal.*

The *lacrymal* (fig. 8*a*) on each side is a small irregular bone wedged in between the pre-frontal on the inside and the posterior border of the maxilla on the outside. The anterior end of the bone is produced into a small triangular process which articulates with the inner surface of the maxilla and forms part of the lateral wall of the olfactory chamber. Posteriorly also, the bone is produced into a short but broad triangular process which is prominently seen at the anterior border of the orbit, just below the base of the supra-orbital (fig. 8*a*). The inner surface of the bone is concave and forms the entire outer border of the orbito-nasal canal. The ventral part of the bone articulates with the jugal and the maxillary process of the palatine and is perforated by a small oval foramen, the *lacrymal foramen*, which provides a passage for the *lacrymal canal*.

The *post-orbitals* (post-frontals of Siebenrock) are a pair of elongated bones, each with a clasp-shaped process on the inner side of its anterior half (fig. 4). The elongated posterior bar of the bone articulates with the squamosal behind and forms the anterior half of the supra-temporal arcade. The outer anterior end of the bone is curved downwards and forms a short thick conical process, the *orbital process*, which is connected by means of a cartilaginous bar with the posterior end of the jugal, thus forming the outer posterior boundary of the orbit. The anterior and inner clasp-shaped process has a deeply concave inner border and closely grips within it the antero-lateral border of the parietal and the postero-lateral border of the frontal bone.

There is a single post-orbital on each side unlike the case in some species of *Lacerta* in which there are two on each side, described by Siebenrock (9) as post-frontal 1 and post-frontal 2.

The paired *jugals* (fig. 8*a*) are slender curved bones forming with the lacrymals the outer ventral boundary of the orbit. Anteriorly each of them is thickened and is triangular in cross-section, but posteriorly it becomes slender and pointed. It articulates anteriorly with the maxilla and the lacrymal, laterally with the transverse, while posteriorly it is connected with the post-orbital through a slender cord of cartilage. Its anterior part articulating with the maxilla is called the *maxillary process*, while its posterior part leading towards the post-orbital is called the *temporal process*. A quadrato-jugal is absent in the skull of the Lacertilia. The loss of this bone evidently leads to a greater mobility of the jaws.

All these four bones are dermal in origin (*investing bones*).

The free bony shields (*lamina superciliaris* and *schläfanpanzer* of Siebenrock) covering the orbit from above and also the temporal region in *Lacerta* are absent in *Varanus*. Thus, the *scuta supraocularia* and the *scuta superciliaria* are absent and so are the *scuta temporalia*.

(c) *Bones in Relation with the Olfactory Capsules.*

The *olfactory capsules* are two fairly large oblong structures occupying the greater part of the facial portion of the skull. They lie in front of the cranial cavity, one on each side of the middle line, and are formed almost completely of cartilage partially protected by bones. Each is bounded behind by the pre-frontal and the lacrymal, and laterally by the lacrymal and the maxilla ; the roof is covered over chiefly by the integument of the face and only partially by the united nasals behind, while the floor is formed by the flat rostral portion of the maxilla and the septo-maxillary in front, and the vomer and the vomerine process of the palatine behind. The two capsules are separated from each other and bounded internally by the nasal process of the pre-maxilla and the cartilaginous nasal septum which extends below and behind this bony nasal process, and continues behind into the inter-orbital septum.

Each olfactory capsule is horse-shoe-shaped in outline and consists of two parts : (1) the *vestibule,* corresponding to the outer limb of the ∩, which begins behind with the external narial aperture and leads forwards right up to the junction of the pre-maxilla and maxilla ; and (2) the *olfactory chamber* corresponding to the inner limb of the ∩ and lying parallel and internal to the vestibule and leading backwards to open into the buccal cavity through the *internal nares* or *choanae.* The vestibule and the olfactory chamber are continuous with each other at the extreme anterior end just behind the pre-maxilla, but are separated from each other along the remaining parts of their lengths by an obliquely vertical cartilaginous partition called the *concha.* The external nares are funnel-shaped ; each is bounded behind by the slightly flattened and gradually ascending anterior border of the maxilla and leads forwards into the vestibule, which extends right up to the pre-maxilla and then turns round on the inner side of the concha to continue into the olfactory chamber. The concha extends forwards and inwards from the posterior border of each external nare along the outer edge of each septo-maxillary, as seen from the dorsal surface.

The united *nasals* (fig. 4) form an elongated, more or less triangular, bone lying immediately anterior to the frontals. The two bones are fused together along the greater part of their length and form a more or less flat plate, but their laterally compressed and conical anterior fourths remain separate, enclosing between them the posterior end of the median nasal process of the pre-maxilla, which extends behind to meet the frontals ventrally beneath the nasals (fig. 11). Posteriorly the nasals present a short median cleft and are produced into two small lateral wing-like processes, each of which closely fits into the concavity and cleft at the anterior end of each frontal. The nasals form a very small part of the roof at the posterior end of each olfactory chamber, the greater part of which is covered by the thick integument of the face. The cartilaginous *inter-nasal septum* is attached to the ventral surface of the frontals and the nasal process of the pre-maxilla in the middle line, the nasals remaining on the dorsal surface of the skull (fig. 11).

The paired *septo-maxillaries* (*turbinals* of Siebenrock) are two small, more or less triangular bones, lying one on each side of the nasal process of the pre-maxilla, between it and the maxilla on the outside (fig. 4).

Dorsally each of these bones is seen to lie just behind the flat rostral portion of the maxilla. A disarticulated bone has the shape of an inverted watch-glass, the hollow being directed ventralwards so as to overlie the anterior part of the vomer and enclose the Jacobson's organ within. The latter communicates with the anterior part of the buccal cavity through a triangular aperture on the roof of the mouth, between the maxilla and the vomer (fig. 1). Along the whole length of its inner border, each septo-maxillary presents a narrow groove, along which runs the *ramus frontalis ophthalmici nerve* (V). At the anterior conical end of the bone this nerve gives off a branch which passes through a *foramen* (*the anterior septo-maxillary foramen*) and runs outwards along the antero-lateral border of the bone and then penetrates inwards to innervate the mucous membrane of the Jacobson's organ.

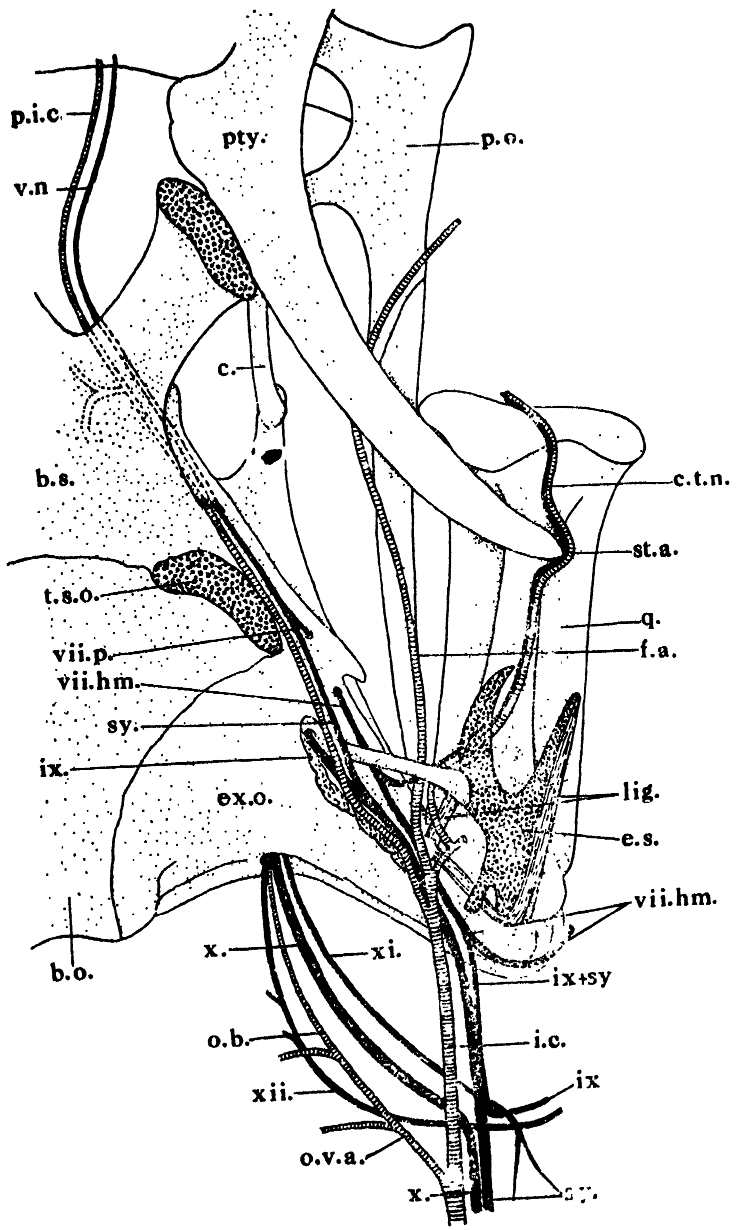
All the bones in relation with the olfactory capsule are dermal investing bones.

IV. The Suspensorium.

The *suspensorium* is formed on each side by the stout pillar-like quadrate, the ventral end (*condylus mandibularis*) of which forms the articular surface for the lower jaw, while the dorsal end is supported and strengthened by the squamosal, the supra-temporal and the paroccipital process of the ex-occipital (fig. 8*a*).

The palatoquadrate cartilage is very much reduced in the Amniota, the only parts remaining being the processus ascendens and the basal process articulating with the basitrabecular process and the quadrate cartilage. The former ossifies as the epipterygoid bone and the basipterygoid process of the basisphenoid and the latter as the quadrate bone (**5**, p. 440).

The *quadrate* is a stout pillar-like bone forming the posterior boundary of the side-wall of the skull and the anterior and outer boundary of the middle ear. It is disposed in an obliquely dorso-ventral direction, the dorsal end being directed backwards and the ventral end slightly forwards. The upper dorsal end (*condylus cephalicus*) is expanded antero-posteriorly and articulates above with the squamosal, the supra-temporal and the paroccipital process of the ex-occipital (fig. 8*a*). Between the articular surface of the quadrate and the paroccipital process, there is a small meniscus of cartilage called the "intercalary cartilage" (*supra* p. 155). This cartilage provides for the movement of the quadrate on the paroccipital process (*streptostylism*). In front of the articulation with the squamosal, there is a more or less rounded facet covered with cartilage for the insertion of the adductores mandibulae externus and medius muscles. The lower end is expanded laterally to form the articular surface for the lower jaw. Close to this articular surface, along its internal border, the quadrate bears a facet for articulation with the pterygoid. Along both of its outer and inner borders, the quadrate is produced into thin elongated ridges, to the outer of which (*tympanic crest*) is attached the anterior margin of the tympanic membrane. The anterior and posterior surfaces are broad; the anterior gives attachment to the adductores mandibulae externus and medius muscles, while the whole of the posterior surface forms part of the cavity of the middle ear.



Text-fig. 13. Ventral view of the left half of the posterior part of the skull showing the relations of the nerves and arteries with the bones (×*ca.* 4½).

b.o., basioccipital ; *b.s.*, basisphenoid ; *c.*, columella cranii ; *c.t.n.*, chorda tympani nerve ; *e.s.*, extra-stapes ; *ex.o.*, ex-occipital ; *f.a.*, facial artery ; *i.c.*, internal carotid artery ; *lig.*, two ligaments, first, between the outer surface of the extra-stapes and the tympanic membrane originating from the intercalary cartilage ; the second also originates from the same cartilage and goes towards the *processus ventralis* of the extra-stapes on which it is inserted ; *o.b.*, occipital branch of the internal carotid artery ; *p.i.c.*, palatine branch of the internal carotid ; *p.o.*, post-orbital ; *pty.*, pterygoid ; *q.*, quadrate ; *st.a.*, stapedial arrery (arteria auricularis) ; *sy.*, sympathetic nerve *t.s.o.*, tuberculum spheno-occipitale ; *v.n.*, vidian nerve consisting of the palatine branch of the VIIth nerve and the sympathetic ; *vii p.*, palatine branch of the VIIth nerve ; *vii.hm.*, hyomandibular branch ; *ix.*, glosso-pharyngeal ; *ix+sy.*, combined ninth and sympathetic nerve ; *x.*, vagus nerve ; *xi.*, spinal accessory ; *xii.*, hypoglossal nerve.

The paired *epipterygoids* (*columella cranii*) are slender rod-shaped bones (figs. 8*a* and 8*b*) which are disposed in an obliquely dorso-ventral direction, the ventral end lying distinctly anterior to the dorsal end. The dorsal and ventral ends of the bone are slightly flattened; the dorsal end fits against the parietal process of the pro-otic, while the ventral fits into a depression (*fossa columellae*) on the dorsal surface of the pterygoid at about the middle of its length.

The *squamosal* (fig. 8*a*) is a thin elongated bone curved posteriorly into a comma-like shape, the head of the comma fitting on to the dorsal end of the quadrate and against the outer surface of the supra-temporal. The anterior end of the bone forming the tail of the comma is directed forwards and fits against the outer surface of the hinder end of the post-orbital, the two bones together (squamosal and post-orbital) forming the superior temporal arcade.

The *supra-temporal* (figs. 4 and 8*a*) is a small bone resembling in shape the *Kukri* (short sword) of the Gurkha soldier. It is curved like the squamosal and its lower hinder end fits on to the dorsal end of the quadrate. Its anterior blade-like portion is sickle-shaped and covers externally the hinder end of the supra-temporal process of the parietal, while its posterior curved end is wedged in between the squamosal externally and the paroccipital process of the ex-occipital internally.

The quadrate and the epipterygoid are endochondral ossifications of the palatoquadrate cartilage but the squamosal and the supra-temporal are dermal bones

V. The Palate and the Upper Jaw.

The palate and the upper jaw are formed of the pterygoids, ectopterygoids (transpalatines), palatines and vomers and the premaxillae and the maxillae. All these are dermal (investing) bones.

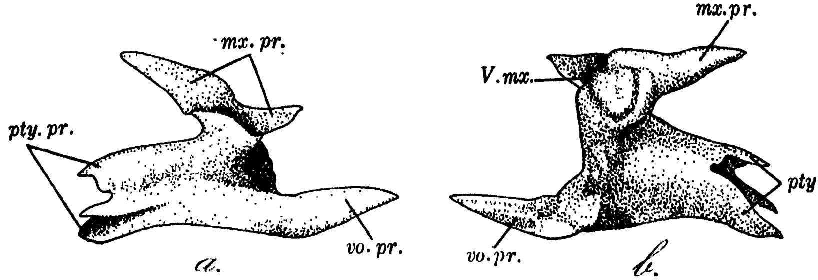
The *pterygoid* (figs. 1 and 8) is an elongated, slightly curved bone, which forms a more or less flat plate in front and a long outwardly directed rod-like process behind. The flat plate is produced in front into an expanded *palatal process* articulating with the palatine, and externally into a conical *transverse process* articulating with the ectopterygoid (transverse). These two processes enclose between them a space which forms the posterior part of the *sub-orbital fossa* (fig. 1). The rod-like *quadrate process* is the longest and rests posteriorly against the inner border of the quadrate, close to its lower end, in such a way that the articulation is movable, the pterygoid sliding on the quadrate. On the dorsal surface, at the junction of the quadrate and palatal processes, lies a slightly elongated but deep pit, the *fossa columellae*, into which fits the lower end of the *epipterygoid* (*columella cranii*); on the inner surface of the pterygoid, about the middle of its length, supported below by a small conical tubercle, lies the articular facet for the basipterygoid process of the basisphenoid. As in *Sphenodon*, there is a cartilaginous meniscus between the basipterygoid process of the basisphenoid and the pterygoid. This meniscus is prominent in the adult *Varanus* and Broom holds that it corresponds to the mesopterygoid of Fishes. The pterygoid in *Varanus* does not articulate with the vomer as it does in *Sphenodon*, *Uromastix*, the Crocodilia and some

Chelonia. Unlike the case in *Lacerta*, the pterygoids of *Varanus* bear no teeth.

Between the pterygo-palato-vomerine bar on the outside and the ventral border of the inter-orbital and inter-nasal septum in the middle line, there is an elongated space called the *incisura piriformis* or the *lacuna pterygo-vomerina* of Siebenrock (fig. 1).

The *transverse* (*ectopterygoid* or *transpalatine*) is a small curved bone (fig. 1), the inner and posterior end of which embraces the transverse process of the pterygoid, while the anterior end fits against the maxilla and the maxillary process of the palatine. The internal concave border of the bone forms the outer boundary of the sub-orbital fossa, while its outer and dorsal convex border articulates all along its length with the jugal.

The *palatine* (figs. 1 and 14) is roughly H-shaped in appearance and has an irregular outline, with *three* differently shaped articulating processes : (1) the anterior process is narrow and elongated ; it is directed antero-mesially and articulates with the vomer in front ; it is therefore called the *vomerine process* ; (2) the posterior process is broad

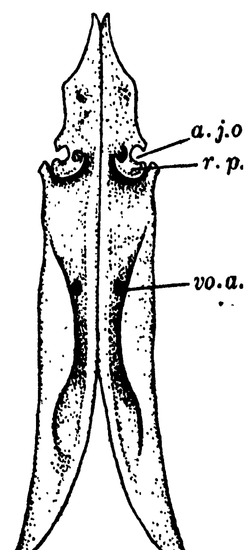


TEXT-FIG. 14. Palatine of the right side (×*ca.* 3).
a., ventral view; *b.*, dorsal view.
mx.pr., maxillary process ; *pty.pr.*, pterygoid process ; *V.mx.*, foramen for the maxillary division of the Vth nerve ; *vo.pr.*, vomerine process.

and is directed backwards and slightly outwards ; it is produced at its distal end into three small conical projections, which articulate immovably with the pterygoid behind ; this process is called the *pterygoid process* ; (3) the third or the outer lateral process is narrow at its origin but is expanded antero-posteriorly at its distal end, which forms an elongated articular surface for the maxilla on the outside ; the pointed posterior end of the process joins the jugal and transverse bones ; this outer process may be called the *maxillary process.* It is perforated by a foramen (*the maxillary* or *palatine foramen*), through which the *superior alveolar nerve* (maxillary branch of the Vth nerve) along with the *inferior orbital artery* and the *vena maxillaris* passes into the long bony canal (*canalis alveolaris superior*) of the maxilla. On the dorsal surface, the anterior concave border joining the vomerine and maxillary processes is produced into a shallow ridge on which are seated the pre-frontal and lacrymal bones. The palatines bear no teeth.

The upper surface of the palatine with the pterygoid behind forms the floor of the orbit, while the anterior smaller portion of the palatine with the vomer forms the floor of the nasal chamber,

The paired *vomers* (figs. 1 and 15) lie, one on each side of the middle line, in front of the palatines, and together form the median part of the roof of the anterior region of the buccal cavity. Looked at from the dorsal surface (fig. 15), the posterior two-thirds of each vomer appears like an open drain-pipe, the outer wall of which is higher than the inner and is slightly curved inwards. Along this drain-pipe canal of the vomer run the *dorsal palatine artery* and the *ramus frontalis ophthalmici of the Vth nerve* and the branch of the olfactory nerve going to the Jacobson's organ. Anteriorly each vomer at first flattens and then becomes pointed at the extreme anterior end, which articulates with and is covered over by the palatal process of the pre-maxilla. At about one-fourth of its length from the anterior end, each bone gives off a very small and slender rod-like process expanding into a small kidney-shaped outgrowth at its end (fig. 15), the process and its outgrowth being so thin and delicate as to be broken off in prepared skulls. In a whole skull this outgrowth projects into the ventral hollow concavity of the septo-maxillary and forms in life a ventral ingrowth into the cavity of the Jacobson's organ. Just behind this process, on each lateral border, there is an articular facet for articulation with the maxilla of each side. Posteriorly each vomer diverges from the middle line and articulates with the palatine of each side, while dorsally the greater part of the vomer is covered over by the septo-maxillary of each side and the nasal process of the premaxilla in the median line.



TEXT-FIG. 15. Dorsal view of the vomers (×*ca.* 3).

a.j.o., aperture for the Jacobson's organ ; *r.p.*, reniform or kidney-shaped process of each vomer which projects upwards into the cavity of the Jacobson's organ ; *vo.a.*, vomerine aperture.

On the ventral surface, the anterior part of the vomers bears a low median ridge flanked by two long oblique ridges, one on each side. Enclosed between the posterior ends of these oblique ridges, there are

two minute foramina, the *vomerine apertures* (figs. 1 and 15), one on each side. Through each of these foramina comes out a small vein from the posterior part of the Jacobson's organ and enters the *sinus palatinus medius* lying immediately beneath the mucous membrane of the roof of the mouth at this place. About half an inch in front of these foramina, there are two large triangular apertures, each enclosed between the vomer and maxilla of its own side, just in front of the articular facet of the vomer fitting against the maxilla ; these are the *openings of the Jacobson's organs* (fig. 1) into the buccal cavity.

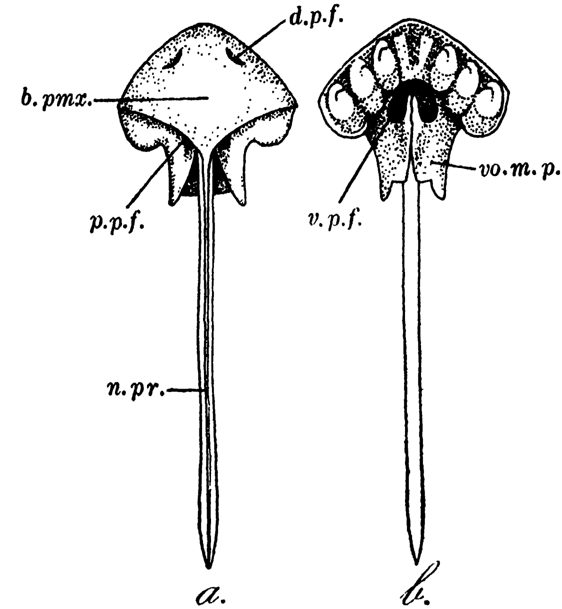
The vomers bear no teeth.

The paired *maxillae* (fig. 8*a*) are extensive bones, more or less triangular in outline, which form the greater part of the face of the lizard, with narrow alveolar and palatal portions. Each maxilla articulates in front with the pre-maxilla, mesially with the septo-maxillary and the vomer and through a piece of cartilage with the nasal process of the pre-maxilla, and posteriorly with the pre-frontal, the lacrymal, the jugal, the transverse and the maxillary process of the palatine. The anterior part of each maxilla is made up of a narrow vertical facial portion and a flattened nasal or rostral portion lying on each side of and in front of the septo-maxillary ; this nasal portion forms the floor of the vestibule of the olfactory capsule. The posterior part of the maxilla is chiefly facial in position and forms a high lateral wall on the outer side of the hinder part of the olfactory chamber. The anterior concave border of the high lateral wall forms the posterior border of the anterior nare on each side. The alveolar portion of the maxilla is narrow except at its anterior end and at its junction with the vomer, where it forms flat palatal processes.

The alveolar portion of the bone is tunnelled through by the *canalis alveolaris superior*, which lodges the *superior alveolar nerve* and the *arteria maxillaris* (p.) 161. The cutaneous branches of this nerve come out through several (8-10) fine openings which lie in a long row, a little above the base of the outer facial part of the bone. Another aperture on the palatal surface between the first group of two teeth and the other group of six or seven transmits the palatal branch of the superior alveolar nerve.

The *pre-maxillae* (figs. 1, 4, 8*a* and 16) of the two sides are united to form a single median *pre-maxilla,* which forms a triangular rostral *body* at the anterior end of the skull and gives off posteriorly a long median laterally compressed sabre-shaped process, the *nasal process.* The posterior end of the nasal process is wedged in between the nasals and extends behind to meet the frontals beneath the nasals, while along the greater part of its length, it divides the two septo-maxillaries from each other and supports the cartilaginous inter-nasal septum behind. The median rostral portion (*body*) gives off on the ventral surface a short *vomero-maxillary process* on each side ; these two processes meet in the middle line and form the anteriormost part of the hard palate, articulating behind with the vomers and laterally with the maxilla of each side. At the junction of the two vomero-maxillary processes in the mid-ventral line, each process is produced into a ridge, the two ridges together forming

a double median ridge projecting in front and overhanging the ventral pre-maxillary foramina.



TEXT-FIG. 16. Pre-maxilla (×*ca.* 3).

a., dorsal view: *b.*, ventral view.

b.pmx., body of the pre-maxilla; *d.p.f.*, dorsal pre-maxillary foramen; *n.pr.*, nasal process of the pre-maxilla; *p.p.f.*, posterior pre-maxillary foramen; *v.p.f.*, ventral pre-maxillary foramen; *vo.m.p.*, vovero-maxillary process.

Three pairs of foramina are seen on the united pre-maxillae. A pair of transversely elongated slit-like foramina perforate the dorso-lateral surfaces of the pre-maxillae. These *anterior dorsal pre-maxillary foramina* look like anterior narial apertures and lead behind into the two *posterior pre-maxillary foramina*, lying one on each side of the root of the nasal process on the pre-maxilla. At the extreme anterior end of the hard palatal vomeromaxillary processes, there are a pair a *ventral pre-maxillary foramina* which also lead into the posterior pre-maxillary foramina. The ventral foramina transmit the anterior small branches of the arteria maxillaris, while the anterior and posterior foramina transmit the *ramus frontalis ophthalmici branch of the Vth nerve*.

The united premaxillae generally carry 8 small teeth on the inner side of their margin.

VI. The Lower Jaw.

The *lower jaw* (fig. 17) consists of two long slightly curved rami, which are united together at their anterior ends through a bony symphysis. Each ramus consists of *six* bones: the *articular* (+*pre-articular*), the *angular*, the *supra-angular*, the *splenial*, the *coronoid* and the *dentary*. The *articular*, with which is united the pre-articular, forms the hinder

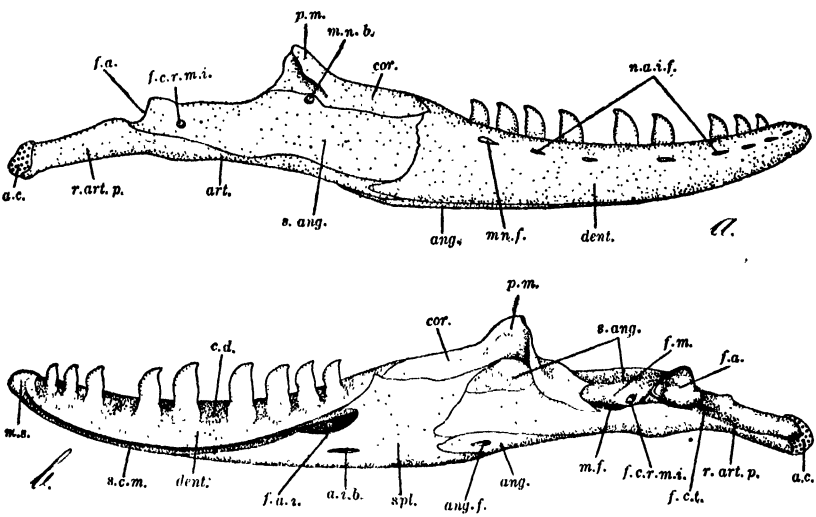
proximal end of the mandible. It is an elongated bone, the posterior part of which is strong and stout, while the anterior part is thin and vertical. The posterior stout part bears on its dorsal surface a transversely concave facet (*fovea articularis*) for articulation with the lower end of the quadrate. The part of the bone behind the articular facet is called the *post-articular process* (*processus retro-articularis*). The outer upper border of this process forms the ventral boundary of the tympanic membrane (fig. 11), while its dorsal surface behind the fovea articularis is depressed to form a shallow *fossa retro-articularis*, at the anterior end of which there is an aperture for the entrance of the *chorda tympani nerve*. The posterior end of the articular is tipped with a piece of cartilage on which is inserted the *musculus depressor mandibulae* (fig. 11). The thin vertical anterior part of the articular fits against the inner surface of the ventral part of the supra-angular. The articular extends over half the length of the mandible on the inner side, and is, in fact, the longest of all the bones of the lower jaw.

Closely fitting against the part of the articular lying in front of the fovea articularis is the *supra-angular*, visible chiefly on the outer surface of the mandible, although partially visible also on the inner and dorsal surfaces. This is a stout laterally compressed bone which expands posteriorly to form a depressed surface, and grips the vertical surface of the articular immediately below and in front of the fovea articularis. About the middle of its length, the supra-angular is produced dorsally into a flat triangular process which fits into the coronoid and is, therefore, called the *coronoid process*.

The supra-angular bears a number of foramina. Close to its posterior end, running through the thickness of the bone from the inner to the outer surface, there is a canal-like perforation into which enters, from the inner surface, the *nervus cutaneous recurrens maxillae inferiores* branch of the mandibular division of the Vth nerve. This nerve comes out on the outer surface almost opposite the leading-in foramen and supplies the skin of this region. Just in front of this foramen, on the inner surface of the mandible, bounded ventrally and internally by the articular, and dorsally and externally by the supra-angular, there is a large elliptical fossa, the *fossa Meckelii*, at the anterior end of which lies the *mandibular foramen*, through this foramen the main trunk of the *mandibular division* of the Vth nerve and the mandibular artery enter the lower jaw, while the mandibular vein comes out of this foramen. The mandibular nerve gives off several branches : one of them comes out through a foramen on the outer surface of the coronoid process of the supra-angular ; another branch canalises the supra-angular all along its length, but the main trunk of the nerve runs in a ventral canal formed by the apposition of the articular and the supra-angular as the *nervus alveolaris inferior*.

When the articular and supra-angular are fitted together, there remains an elongated cleft between the anterior thirds of their ventral borders ; this cleft is filled up in the complete lower jaw by the *angular*, which is a short and thin splint-like bone, being, in fact, the smallest of the six bones of the mandible. The greater part of the angular is wedged in between the articular and the supra-angular, while a

small anterior part lies in between the dentary on the outside and the splenial on the inside. About the middle of its length, the angular bears a foramen which leads into the *canalis alveolaris inferior*, and transmits the angular branch of the *nervus alveolaris inferior*.



TEXT-FIG. 17. The mandible (×*ca.* 2).

a. from the outer side; *b*. from the inner side.

a.c., articular cartilage; *a.i.b.*, foramen for a branch of the nervus alveolaris inferior; *ang.*, angular; *ang.f.*, angular foramen; *art.*, articular; *c.d.*, crista dentalis; *cor.*, coronoid; *dent.*, dentary; *f.a.*, fovea articularis; *f.a.i.*, foramen for the main trunk of the nervus alveolaris inferior; *f.c.r.m.*, foramen for the cutaneous recurrens maxillae inferiores branch of the mandibular division of the Vth nerve; *f.c.t.*, foramen for the chorda tympani branch of the VIIth nerve; *f.m.*, fossa Meckelii; *m.f.*, mandibular foramen for the entrance of the mandibular division of the Vth nerve and the mandibular artery; *m.n.b.*, foramen for a branch of the mandibular nerve; *mn.f.*, mental foramen; *m.s.*, surface of the mandibular symphysis; *n.a.i.f.*, foramina for the branches of the nervus alveolaris inferior (mandibular division of the Vth nerve); *p.m.*, processus messetericus; *r.art.p.*, processus retro-articularis; *s.ang.*, supra-angular; *s.c.m.*, sulcus cartilaginis Meckelii; *spl.*, splenial.

The *dentary* forms the greater part of the distal half of the mandible. Its inner surface is partially covered by the *splenial*, while on its outer surface it is fully exposed and presents a long row of eight foramina, the most posterior of which is called the *mental foramen* for the exit of the *mental branch* of the inferior alveolar nerve. The bone is canalised all along its length by the *nervus alveolaris inferior*, which gives off several branches, each coming out of one of the eight foramina of the row. The upper inner border of the dentary, called the *crista dentalis*, bears nine teeth. Along its ventral and inner border runs an open channel, narrow in front but wide behind, called the *sulcus cartilaginis Meckelii*, into which fits the persistent part of the *Meckel's cartilage*. The anterior end of the dentary is slightly flattened on its inner surface and fits against a similar surface of the dentary of the other side to form the *symphysis mandibularis*. The posterior end of the dentary has a concave border and a deep notch into which fits the anterior end of the supra-angular.

The *splenial* consists of a thin vertical quadrangular part and an elongated horizontal splint-like part. The vertical part partially covers internally a part of each of the articular, supra-angular, coronoid and dentary bones and serves to hold all these bones together, while the lower horizontal part forms the inner surface of the ventral border of the mandible and serves to hold the angular in position. On the inner surface of the mandible, between the anterior border of the splenial and the lower border of the dentary, there is a large elliptical notch, the greater part of which lodges the posterior end of the Meckel's cartilage, while at the bottom of the notch there is a foramen through which the *inferior alveolar nerve* enters the dentary.

The *coronoid* is an elongated triangular bone which is slightly twisted and is seated on the coronoid process of the supra-angular. It articulates posteriorly with the articular and the supra-angular and anteriorly with the splenial and the dentary. Along its ventral border, it presents a shallow groove into which fits the upper border of the coronoid process of the supra-angular. The posterior end of the bone forms the anterior boundary of the mandibular foramen in the fossa Meckelii, while the vertex of the bone in the complete skull projects upwards into the lateral temporal fossa to form the *processus messetericus*. The outer posterior border of the coronoid along with the upper border of the supra-angular serves for the attachment of the adductores mandibulae externus and medius muscles.

Of the six bones of the lower jaw, the articular alone is an endochondral ossification, while the other five are dermal bones.

VII. Temporal arcades and fossae and other large vacuities.

The temporal region of the skull is strongly built and bears a lateral bridge or arcade called the *superior temporal arcade* (figs. 3 and 8*a*), formed by the post-orbital and the squamosal ; a second arcade, the *inferior temporal arcade*, formed by the jugal and quadrato-jugal in *Sphenodon* and the Crocodilia amongst recent reptiles, is absent in *Varanus*, there being no quadrato-jugal in *Varanus*. We get three fossae in the temporal region : (1) a more or less triangular *superior temporal fossa* (figs. 4 and 10) on the roof of the skull on each side, bounded externally by the superior temporal arcade and internally by the parietal and supra-temporal ; (2) a confluent *lateral* and *inferior temporal fossa* bounded above by the superior temporal arcade, below by the pterygoid and behind by the quadrate ; and (3) a *post-temporal fossa* (*foramen retro-temporale* of Siebenrock) on the posterior aspect of the skull (fig. 6), which is more or less triangular in outline and is bounded above by the post-temporal process of the parietal and below by the supra and ex-occipitals and the pro-otic. In life, these temporal fossae are filled in by the adductor mandibulae muscles and the extensor muscles of the head.

Lying in front of each superior temporal fossa is the incomplete *supra-orbital fossa* (fig. 3) on each side, bounded by the supra-orbital and pre-frontal in front and the frontal and post-orbital internally and behind. It is incomplete on its outer and hinder aspects, as there

is no bony connection between the supra-orbital and the post-orbital, the two being joined only by a cartilaginous bar.

On the ventral surface of the skull in its posterior region, there is a large quadrangular vacuity on each side, bounded internally by the outer edge of the floor of the cranium and externally by the quadrate and the quadrate process of the pterygoid. In the living condition, the tympanic membrane stretches across the hinder part of this vacuity, which is really the *cavity of the middle ear.* In front of these two vacuities, lying beneath the optic capsules, there are two elongated oval apertures, one on each side, surrounded by the pterygoid, transverse and palatine bones. These are the *sub-orbital fenestrae.* In the middle, there are two large cavities lying one on each side of the parasphenoid and the inter-orbital septum in the mid-ventral line, and bounded externally by the pterygoids and palatines: these (fig. 1) are called the *incisura piriformis* (*inter-pterygoid fissures*). In front of these fissures there are a pair of large elongated elliptical openings, the posterior portions of which form the *choanae* or the *internal nares* (fig. 1).

VIII. The Foramina of the Skull.

(*a*) *Dorsal Surface* (fig. 4).

1. The *dorsal pre-maxillary foramina* are a pair of small slit-like apertures, one on each side of the middle line, on the dorso-lateral surfaces of the body of the united pre-maxillae. In a dry skull they look like a pair of external nostrils. Through these emerge two short terminal branches of the *ramus frontalis ophthalmici* of the deep ophthalmic division of the Vth nerve to supply the skin of the snout.

2. The *posterior pre-maxillary foramina* are a pair of small apertures, one at each angle between the median nasal process of the pre-maxilla and the body of the pre-maxilla. These apertures lead through very short canals within the united pre-maxillae to the dorsal pre-maxillary foramina. The *ramus frontalis ophthalmici* enters the pre-maxilla through each of these two apertures.

3. The *anterior septo-maxillary foramina* are a pair of apertures, at the anterior end of each septo-maxillary. Each of these transmits a lateral twig of the *ramus frontalis ophthalmici* along with a small vein.

4. The *dorsal septo-maxillary foramina* are a pair of small apertures as shown in fig. 4. They also transmit a branch of the *ramus frontalis ophthalmici* of the Vth nerve.

5. The *posterior septo-maxillary foramina* are a pair of small apertures, each at the posterior end of each septo-maxillary. The *ramus frontalis ophthalmici* enters this foramen to run forwards along the inner border of the septo-maxillary all along its length.

6. The *anterior narial openings* are a pair of oval apertures, one on each side on the maxillae. Each is bounded anteriorly by cartilage and posteriorly by the ascending anterior border of the maxilla. These openings lead forwards on each side into the vestibule which turns backwards into the olfactory chamber proper, opening behind into the choanae or internal nares. In a dry skull, therefore, the posterior end alone of the place for the olfactory chamber represents anterior nares proper (fig. 4).

7. The *parietal foramen* is a prominent median aperture lying in the middle line of the united parietals. It lodges the parietal organ.

(*b*) *Ventral Surface* (fig. 1).

1. The *ventral pre-maxillary foramina* lie on the ventral surface of the pre-maxilla on each side of the anterior end of the median ridge. A branch of the *arteria maxillaris* comes out of each of these foramina to supply the mucous membrane of this region.

2. The *apertures for the Jacobson's organs* are two large triangular apertures, one on each side, between the anterior part of each vomer and the palatal process of the maxilla. The Jacobson's organs communicate through these apertures with the buccal cavity, the apertures on the mucous membrane of the roof of the mouth in a whole specimen being slit-like in appearance.

3. The *anterior maxillary foramina* are a pair of apertures, each situated just on the outside of the aperture for the Jacobson's organ. Through this aperture, the *superior alveolar nerve* and the *arteria maxillaris* leave the alveolar canal of the maxilla and run forwards supplying branches to the mucous membrane of the anterior region of the hard palate.

4. The *vomerine apertures* are a pair of apertures on the vomers lying one on each side of the middle line. A venule from the Jacobson's organ comes out through each of these apertures and enters the *sinus palatinus medius*.

(*c*) *Lateral Surface* (figs. 2*a*, 3 and 7*a*).

1. The *fenestra ovalis* is a small aperture, lying at the antero-lateral end of the ex-occipital and bounded anteriorly by the pro-otic. It lies immediately above the fenestra rotunda being separated from it by a narrow bony ridge. The inner end of the stapes fits into the fenestra ovalis. In dry skulls, the fenestra ovalis is seen to open internally into the cavity of the internal ear but sometimes the inner cartilaginous end of the stapes remains and clogs the fenestra.

2. The *fenestra rotunda* is a large elliptical aperture which lies immediately below the fenestra ovalis and is bounded by the ex-occipital except at its anterior end where it is closed by the *tuberculum spheno-occipitale* cartilage. The aperture leads into a small space the *recessus scalae tympani*, in which lies the *saccus perilymphaticus*, the outer wall of which forms the *secondary tympanic membrane* closing the fenestra rotunda. On the posterior wall of this fenestra runs the *glossopharyngeal nerve* (IXth) which leaves the fenestra at its posterior end.

3. The *posterior facial foramen* is a very small aperture lying in front of the fenestra ovalis at a slightly higher level. It perforates the pro-otic bone and is overhung by the backwardly directed conical process of the pro-otic (*otosphenoidal crest*). The *hyomandibular division of the facial* (VIIth) *nerve* leaves the skull through this foramen.

4. The *anterior facial foramen* is also a small aperture lying in front of the posterior facial foramen and perforating the pro-otic bone. Through it the *palatine branch of the facial nerve* leaves the skull.

5. The *canalis vidianus* (*ductus caroticus*) is a short canal which perforates the basisphenoid bone on each side. Its posterior opening lies in front of the anterior facial foramen at a slightly lower level. Through it the *palatine division of the facial nerve* and the *internal carotid artery* perforate the basisphenoid bone to run forwards. During their passage through the canalis vidianus, the internal carotid gives off an *intra-cranial branch* which enters the cranial cavity through the hypophysial fossa, while the palatine branch of the internal carotid and the palatine branch of the facial come out through the anterior opening of the vidian canal to run forwards on the roof of the mouth. The palatine branch of the seventh nerve receives a *sympathetic branch from the ninth nerve* (fig. 13) and is, therefore, called the *vidian nerve*, which gives the name *canalis vidianus* to the passage through the basisphenoid.

6. The *optic fenestrae* (figs. 2*a*, 8*a* and 9) are two large oval apertures, one on each side, for the exit of the optic nerves. The two minute orbito-sphenoids enclose the optic chiasma between them, but as the inter-orbital septum lies in the middle line immediately below these bones, the common optic fenestra above is seen to be divided into two fenestrae ventro-laterally, each providing an exit for the *optic nerve* of its own side. Each optic fenestra is thus bounded by the orbito-sphenoid externally and the inter-orbital septum internally.

7. The *orbito-nasal canal* is a large oval aperture bounded internally by the pre-frontal and externally by the lacrymal. It lies at the extreme anterior angle of the orbit and is hidden from the lateral surface by the outer conical process of the lacrymal. Through this aperture, the orbit is placed in communication with the nasal chamber.

8. The *lacrymal foramen* is a small aperture perforating the ventral part of the lacrymal bone and lying below the orbito-nasal canal.

9. The *maxillo-palatine foramen* lies below the lacrymal foramen and perforates the outer maxillary process of the palatine bone. Through this aperture, the *maxillary division of the trigeminal nerve* enters the upper jaw and continues forwards into the bony canal of the maxilla as the *superior alveolar nerve*, giving off branches all along its length to the skin on the outside of the maxilla through a row of minute apertures all along the outer surface of the lower border of the maxilla.

(*d*) *Posterior Surface* (fig. 6).

1. The *foramen magnum* is the large median aperture, almost circular in outline, at the posterior end of the skull. It is bounded by the four occipital bones and forms an important landmark where the medulla oblongata of the brain passes out into the spinal cord.

2. The *foramen lacerum posterius* + *hypoglossal foramen* is an obliquely oval aperture on each side of the foramen magnum perforating the ex-occipital. It transmits the *pneumogastric* or *vagus* (X),

spinal accessory (XI) and *hypoglossal* (XII) nerves and the *vena cerebralis posterior branch* of the *internal jugular vein* and the *occipital branch* of the *internal carotid artery.*

(*e*) *Longitudinal Section* (figs. 2*b*, 8*b*, 10 and 13).

1. The *hypoglossal foramen* is a small rounded foramen situated on the ex-occipital a little in front of its posterior border. It lets through the *hypoglossal nerve* and opens externally into the jugular foramen or foramen lacerum posterius.

2. The *foramen for the spinal accessory nerve* is a very small foramen lying just above the hypoglossal foramen. This foramen, like the hypoglossal, opens into the jugular foramen and transmits the *spinal accessory nerve.*

3. The *jugular foramen* is a large dorso-ventrally elongated aperture situated just in front of the hypoglossal and spinal accessory foramina. The *vagus nerve* and the *vena cerebralis posterior branch of the internal jugular vein* leave the cranial cavity and the *occipital branch of the occipito-vertebral artery* enters through this foramen. The hypoglossal and spinal accessory foramina open into the jugular foramen and consequently the foramen on the posterior surface of the skull is a combined foramen lacerum posterius and hypoglossal foramen (*vide supra*).

4. The *foramen perilymphaticus* or *glossopharyngeal foramen* is a fairly large oval foramen at the junction of the pro-otic, opisthotic part of the ex-occipital and the basi-occipital. Through it, the *glossopharyngeal nerve* leaves the cranial cavity, while the *ductus perilymphaticus* enters the cranial cavity.

5. The *foramen acusticum posterius* lies about a quarter of an inch above the foramen perilymphaticus at the junction of the pro-otic and opisthotic bones. It transmits the *ramus acusticus posterior* division of the auditory nerve.

6. The *foramen acusticum anterius* is a small foramen on the inner wall of the pro-otic lying anterior to and at the same level with the *foramen acusticum posterius.* This foramen transmits the *ramus acusticus anterior* division of the auditory nerve.

7. The *facial foramen* is a small aperture lying below and slightly anterior to the *foramen acusticum anterius.* The *facial nerve* (VII) leaves the cranial cavity through this foramen and divides within the bone into two branches which emerge separately on the outside of the skull through the anterior and posterior facial foramina.

8. The *foramen* for the *abducens nerve* lies on the dorsal surface of the anterior part of the basisphenoid bone. This nerve perforates the base of each alar process by a very short canal and comes out through a *foramen* in the dorsal part of the hypophysial fossa.

9. The *hypophysial fossa* appears in a longitudinal section as a triangular pit, in the dorsal part of which opens the foramen for the abducens nerve, while laterally there is a large *foramen leading into the*

canalis vidianus through which the intra-cranial branch of the internal carotid enters the hypophysial fossa and in which is lodged one of the two lateral diverticula of the recessus infundibularis.

3. STREPTOSTYLISM AND KINETISM.

Stannius applied the term *streptostylic* to describe those skulls in which the quadrate was freely movable. The Lacertilian skull shows a typical streptostylic condition in that " the bony quadrate is isolated from the epipterygoid (*columella cranii*) and is only connected somewhat loosely to the pterygoid below and the parotic process above by ligament " (**5**, p. 433). In *Varanus*, the inner border of the lower end of the quadrate is movably articulated with the pterygoid, while dorsally the quadrate is joined to the squamosal and supra-temporal above and the paroccipital process of the ex-occipital behind in such a manner as to render movement possible. Further, the lower end of the quadrate (*condylus mandibularis*) articulates movably with the mandible. The quadrate, therefore, is movable at all its joints with the other bones and consequently the skull is truly *streptostylic*.

In addition to streptostylism, the skull of *Varanus*, like that of other Lacertilia, shows " a certain degree of looseness and consequent power of motion between the dermal roofing bones (parietals and frontals) and the posterior brain-case." This phenomenon has been termed *Kinetism* of the skull by Versluys *et al* (**6**). We have already seen that the occipital bones (supra-occipital, ex-occipitals and the basi-occipital) are immovably articulated with the basi-sphenoid and the pro-otic. These six bones form a compact rigid structure which moves as one piece and is termed, for convenience, the *occipital segment* (posterior brain-case). The remaining part of the skull consisting of the quadrate, squamosal, supra-temporal, parietal and frontal on the one hand, and the pterygoid, palatine, transverse, maxilla, and pre-maxilla, on the other, together constitutes the *maxillary segment*. These two segments move on each other at various places.

The junction between the supra-occipital and the parietal is formed of fibrous tissue and thus forms a loose vertically movable joint, the movement being limited only by the cone-shaped processus ascendens tecti synotici cartilage which fits closely into the parietal fossa. Similarly, the anterior superior process of the pro-otic is connected loosely with the lateral bevelled border of the parietal. The basipterygoid processes of the basisphenoid are movable on the pterygoids, as the articulation through the cartilaginous meniscus forms a synovial joint. Lastly, the paroccipital process of the ex-occipital is movably articulated with the quadrate and the supra-temporal through the intercalary cartilage. It must, further, be noticed that in front of the " occipital segment " the lateral walls and floor of the cranium, as well as the inter-orbital septum are composed only of cartilage and membrane ; these structures are therefore not rigid and would permit of a slight movement.

It is thus clear that there are *four* places (not *three* as stated by Edgeworth, (**4**, p. 62) at which the occipital segment is movable

on the maxillary segment. The movement is brought about by the action of the protractor pterygoidei, pterygo-sphenoidalis posterior and pterygo-parietalis muscles (**5**, p. 434) and consists, as pointed out by Bradley (**2**, p. 484), of a movement of elevation and depression of the maxillary segment on the occipital segment which itself remains fixed. The kinetism, therefore, is very marked in *Varanus* and such a skull is termed *metakinetic*.

4. SUMMARY.

1. The skull of *Varanus* is well ossified, although there are important cartilaginous structures, chief of which are the olfactory capsules, the planum supra-septale and its lateral extensions, the tuberculum spheno-occipitale and the intercalary cartilage.

2. The muscles inserted on the basi- and ex-occipitals and also on the tuberculum spheno-occipitale are described. Similarly, the origin and insertion of the adductor mandibulae and depressor mandibulae muscles have been included.

3. All the foramina of the skull have been listed, and the nerves and blood-vessels entering or coming out of these foramina have been identified and described.

The *foramen internum* of Siebenrock has been identified and it has been shown that it transmits the VIth nerve and not a branch of the internal carotid artery, as he believed.

4. The different bones have been compared with those of *Lacerta* and *Sphenodon* and the differences noted. The orbito-sphenoids and their exact relationship with contiguous cartilages have been described and sketched, these having been incorrectly represented by Reynolds.

5. The diagrams of previous authors have been critically examined and corrected and new standard diagrams of the skull have been provided.

6. The streptostylism and metakinetism of the skull have been described.

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INDIAN EARTHWORMS. I. THE GENUS *PHERETIMA*.

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CONTENTS.

	Page.
Introduction	175
Distribution	176
I. P. *alexandri, anomala, campanulata, houlleti, planata* and *posthuma*	178
II. *P. diffringens, hawayana, morrisi* and *robusta*	183
III. *P. elongata, bicincta* and *taprobanae*	185
Habits	187
Systematics	187
Genus Pheretima—	
Diagnosis and notes on certain characteristics and variations	187
Descriptive and diagnostic terms and conventions	188
Miscellaneous notes	191
Key to Indian species	191
Abnormal forms	192
Key to abnormal forms	192
Pheretima alexandri (Beddard) 1900	192
Pheretima anomala Michaelsen 1907	193
Pheretima bicincta (E. Perrier) 1875	195
Pheretima campanulata (Rosa) 1890	197
Pheretima diffringens (Baird) 1869	198
Pheretima elongata (E. Perrier) 1872	201
Pheretima hawayana (Rosa) 1891	202
Pheretima houlleti (E. Perrier) 1872	203
Pheretima morrisi (Beddard) 1892	205
Pheretima planata Gates 1926	207
Pheretima posthuma (L. Vaillant) 1868	207
Pheretima robusta (E. Parrier) 1872	209
Pheretima taprobanae (Beddard) 1892	209
Appendix to the genus *Pheretima*	210
References	211

INTRODUCTION.

Since 1872 more than a score of species have been erected for Indian forms or listed or reported from India. After examination of most of the material (Bourne's specimens apparently have not been preserved and a few other specimens of less importance have not been available for examination), it is now possible by the exclusion of mistaken records, elimination of forms probably belonging to other genera and the reduction of several names to synonyms to bring the number of species to 12, to which one hitherto unrecognized species must be added. All these 13 species now can be defined adequately, though the extent of variation of certain important characteristics of three of the species still remains to be determined. Barring accidental importation by man or

otherwise it is probable that no further species of *Pheretima* will be added to the Indian fauna, at least so far as the area south of the Himalayas and west of Assam and Chittagong is concerned (but see p. 186).

In this paper India is regarded as comprising political India, except that Nepal is included and Burma, the Andaman and Nicobar Islands are excluded. The inclusion of Ceylon would necessitate no additions to the list of species. Moving the eastern boundary of India into Burma nearly to the Irrawaddy in the north and nearly to the Shan Plateau in the south would require the addition of only one species, *P. peguana.*

The author's thanks are extended to Dr. B. Prashad for the loan of a considerable number of specimens from the collections of the Indian Museum as well as of books from the library of the Zoological Survey of India, and to the college geographer, Mr. L. W. Trueblood, for assistance in placing localities and determination of elevations.

DISTRIBUTION.

Michaelsen in his 1909 and 1910 lists characterized almost all of the Indian species of *Pheretima* as peregrine or of doubtful status, with suggestions that the dubious names are synonyms of peregrine species. A single species is regarded as "probably endemic" (*anomala*, 1909, p. 119) but in the list in the same paper the term endemic is preceded by an interrogation mark and followed by "aus botanisch Garten !".

The term "peregrine" was introduced by Michaelsen in 1903 to characterize species widely spread through their own inherent powers of migration or as a result of accidental transference by man. "Ich bezeichnete deshalb Arten mit einer derartig weiten Verbreitung überland, einerlei ob Verschleppung durch den Menschen oder Ausbreitung auf natürlichen Wege vorliegt, als 'Weitwanderer' und vereinigte sie unter der Bezeichnung 'peregrine Formen' mit den sicher Verschleppten". (1903, p. 17). "Das hauptsächlichste Merkmal für Verschleppungsfälle bei Regenwürmern ist eine sehr weite, und zumal auch eine sprungweise Verbreitung übersee, sowie auch das sporadische Auftreten weit entfernt von dem Gebiet, das als das Hauptquartier der betreffenden Gattung anzusehen ist". (p. 16). Endemic is explained as follows: "Eine Art, die lediglich in einem eng begrenzten Gebiet vorkommt, ist als endemisch in demselben anzusehen". (p. 17). Michaelsen recognized that the very numerous gaps in our knowledge of the distribution of earthworms necessitated some further indication of endemicity and accordingly adds "Eine Anzahl nahe verwandte Arten, die lediglich in einem eng begrenzten Gebiet vorgefunden wurden, sind als endemisch in demselben anzusehen". (p. 17).

Stephenson (1923) refrained from using the terms peregrine and endemic in his lists but indicated by difference in type those species which are considered to be of zoogeographical value or with no such value. No clue is given as to how "zoogeographical value" was determined though peregrine forms are said to be of no importance. "Semi-peregrine forms" however are italicized. Only five species of *Pheretima* are regarded as having zoogeographical value. Of these, *burliarensis* is probably not a *Pheretima*, at all, *travancorensis* and *trivandrana* are merely synonyms of *houlleti*, a widely spread form of "no zoogeographical value", while *alexandri* is the same as Stephenson's *lignicola*, a species also considered to be of no zoogeographical importance. This leaves only *anomala* which is known now to be distributed widely throughout Burma and also present in Siam. Presumably all of the Indian species of *Pheretima* would be considered by Michaelsen as peregrine, or at least as "etwas peregrine", or by Stephenson as of no zoogeographical value.

It is true that a number of the Indian[1] species of *Pheretima* have been carried far and wide and have been able to establish themselves in a number of localities far removed from their original habitat. Beddard in 1900 characterizes the distribution of *P. heterochaeta*, now known as *diffringens*, as " everywhere, including Europe ". Gates, in a paper on " The genus *Pheretima* in North America ", now in the press, recognizes 13 American[1] species of which 8 are also Indian. It is likewise true that several species of *Pheretima* are more or less widely distributed throughout India. But the common occurrence of certain species in those (relatively few) localities from which collections have been made and the wide accidental transference have been so over-emphasized that important and almost obvious aspects of distribution have been overlooked. Such statements as " being a well-known peregrine form, the occurrence is of no importance from a zoogeographical point of view " (Stephenson, 1915, p. 37) and " It is scarcely necessary any longer to particularize concerning the distribution of this almost ubiquitous worm, at any rate in those provinces where it has already been found " (Stephenson, 1917, p. 385) are especially unfortunate as they may have been responsible for a failure to record the presence of certain species in important localities.

Beddard's characterization of the distribution of *heterochaeta* is obviously to be taken as an epigram rather than literally. There are many regions to which the species might have been carried and within which it might have become established but from which *P. diffringens* is quite unknown. Expressions such as " one of the commonest worms in India " (Stephenson, 1923, p. 302), " almost ubiquitous ", " Throughout India " (1923, p. 304) and " universally found " (1923, p. 311) have certainly led to misconceptions. To mention but one of these, Bahl (1936, p. 8) says that " *Pheretima posthuma* is found *nearly all over* India, Burma and Ceylon " (italics mine). This statement is incorrect or at least conveys an altogether erroneous impression for the species is quite unknown from large sections of Burma, including some sections which have been fairly thoroughly investigated, and in the districts in which it has been found, is restricted (largely, though not entirely) to a fairly limited habitat. Furthermore, no record can be found of the occurrence of the species in Ceylon. The statement is also too optimistic so far as India is concerned as a glance at the distribution on p. 182 will show.

Before proceeding to a discussion of the individual distribution of Indian species of *Pheretima* it is again necessary to emphasize certain aspects of our knowledge of Indian earthworms. Systematic collection and study of earthworms has been carried out hitherto only in the Punjab and in Travancore (Aiyer, 1929). Accordingly it is still true " that India is so large and diversified that all that has been done is really not much more than the taking of a few samples here and there " (Stephenson, 1915, p. 17). Therefore, in spite of the memoirs on Indian earthworms that have been published since 1909, any discussion of distribution must still be characterized by considerable caution, as " we

[1] The term Indian or American as used in this paragraph implies only that the species is known from India or America.

are still far from a complete acquaintance with the distribution of Indian earthworms, and......any conclusions based on the absence of any forms from this or that region are liable to be upset at any time" (Stephenson, 1915, p. 37).

During the past 13 years considerable work has been done on the earthworms of Burma. This work, though still far from complete, has been extensive enough to warrant certain conclusions though based on absence of forms from especial areas. Such conclusions, if found to be applicable in India, are less likely to be upset even though our knowledge of Indian distribution be fragmentary. The consideration of each of the Indian species is prefaced therefore by a statement of the Burmese distribution and, when possible, by some indication as to the Siamese, Indo-Chinese, Chinese or Malayan distribution. However, it should be noted that very little is known of the earthworms of Siam and not a great deal more of the worms of the Malay Peninsula or French Indo-China.

I.

P. alexandri. This species is widely distributed in central and eastern Burma, having been found in 27 of the 40 districts or political divisions (the Northern and Southern Shan States and Karenni each counted as a district). The worm is equally common on the plains and in the hills, and on the Shan Plateau has been found up to an elevation of 4,000+feet. There is no reason to suspect that the species is lacking in those few districts of central and eastern Burma where collections have not yet been made or where it has not yet been found. At present the species appears to be absent from the Arakan Division and the Chin Hills district of western Burma, but it has been collected at Chiengrai, Chiengmai, Mu'ang Pong (Ban Muang) on the Me Yom, in Upper Siam, Bangkok, Kosichang (on the Gulf of Siam) in Lower Siam, and is also known from Yunnan (Lawng Neu in Mong Lem State) and the Andaman Islands.

A line drawn on a map from Mergui through Siam just east of Bangkok to Chiengmai and then through Mong Lem State into Myitkyina district and from there south to the Chindwin and along the eastern side of the Arakan Yomas to the Bay of Bengal will enclose an area that is compact and which lacks just those physical barriers such as the snow-covered mountain ranges, deserts, or salt seas which are usually regarded as effective in restricting the migration of earthworms. Although compact, the area is not homogeneous with respect to climatic, physiographic and edaphic factors but this seems to be of no particular importance in view of the ability of the species to maintain itself in a variety of habitats in both plains and hills. Since accidental transference is not necessary to explain the distribution of the species within the region just outlined, it is possible to regard this area as the natural range of the species and to conclude that the species originated at some point therein. Though this region is compact Michaelsen might not regard it as an "eng begrenzten Gebiet". But how far from its point of origin can a species migrate within a compact region and still be considered endemic?

The presence of *alexandri* in Bombay as well as on the Andaman Islands, for the present at least, must be regarded as due to accidental transportation.

When a species is found in an isolated locality far from its natural range, such a discontinuous distribution can be explained by assuming that the species has been carried by some external agent to the isolated locality or else that the species has become extinct in the intervening area. Extinction can be disregarded so far as the genus *Pheretima* and south-eastern Asia are concerned.

Earthworms are known to have been carried unintentionally by man, for quite considerable distances. Similar accidental transportation by birds, cattle or other non-human agencies have been postulated but not demonstrated. (I have been told of the finding of cocoons of *Pontodrilus bermudensis* on feet of birds but can find no record of this.) It is possible, if not probable, that most instances of accidental carriage mentioned in this paper are to be attributed to man, but whether this be true or not, the agent or agents involved in the transport to 'foreign' regions are not of importance in the present discussion.

If *alexandri* is really absent from western Burma the Calcutta record also will have to be regarded as due to accidental carriage.

The other Indian locality, Dibrugarh in Assam, is less than 200 miles from the nearest Burmese locality. The earthworm fauna of the intervening region, unlike that between Burma and Calcutta, is unknown. There is however no reason to assume that *alexandri* has been unable to push through the intervening region or that it is lacking therein. Dibrugarh is the northernmost record and it should be noted that *alexandri* has never been found in the Himalayas especially at those higher elevations at which *diffringens* has been obtained.

P. anomala. This species is widely spread throughout the province of Burma and has been found in 29 of the 40 political districts. It is known from the Arakan division and the Chin Hills district in which *alexandri* has not yet been found and is common both in the plains and on the Shan Plateau where it has been found up to an elevation of 4,000+feet. There is no reason to suspect that the species is lacking in the 9 central and 2 peripheral districts which have not yet been investigated or in which it has not yet been secured. The species has been collected in Siam (Chiengrai) and in the Chinese province of Yunnan (Mong Mong State) but is unknown from the Malay Peninsula and the Andaman Islands.

A line drawn on the map to mark off the *anomala* range passes from a point southeast of Mergui north to Chiengrai, through Mong Mong (Yunnan) and Pang Long (Burma) States into Myitkyina district and then in a southerly direction west of the Chindwin river and the Arakan Yomas to Akyab. The area thus demarcated is compact and approximately of the same size as the *alexandri* area. Within this area *anomala* seems to adapt itself equally well to the varied habitats offered by the hills, the Plateau, the monsoon tropics and the semi-arid central zone. (This distribution is especially impressive in view of the constantly occurring high percentage of abnormal forms.)

The three Indian localities of *anomala* are at some distance from the natural range of the species as indicated above, the two easternmost localities about 300 miles (Calcutta) or 400 miles (Darjiling district) from the western boundary of the area in Burma. The other Indian locality (Dehra Dun) is about 700 miles west from Darjiling district. In the intervening region between Burma and the Indian localities the

physical features (such as snow-covered mountains, etc.) that prevent earthworm migration are lacking. In view of the ability of the species to maintain itself in a variety of habitats and to perpetuate itself in spite of the large percentage of abnormal and sexually non-functional individuals, there is no reason to conclude that the species has been unable to penetrate into Bengal to Calcutta and to Darjiling district by its own activity, providing only that sufficient time for such migration has been available. On this latter topic no information whatever is available. At present the three Indian records appear to be the result of accidental transference and especially the Dehra Dun record. It should be noted however that the western border of the *anomala* area is close to the political boundary of India and probably will have to be moved in the future into India.

Dehra Dun and Pashok (Darjiling district) are the northernmost records. Unfortunately the elevations at which the worms were secured are unknown. Although known from lower elevations in the southern Himalayas, *P. anomala*, like *alexandri*, has not been found at those higher elevations at which *diffringens* has been obtained.

P. campanulata. This species is widely spread throughout the province of Burma and has been found in 24 of the political districts. It has been obtained, like *anomala*, from the Arakan division and the Chin Hills district where *alexandri* is unknown, and is common both in the plains and hills and on the Plateau where it has been found up to an elevation of 4,000+feet. The species is known from the Chinese province of Yunnan (Ang Lawng Mt., and Mong Ma, Mong Lem State) and has been found at Mu'ang Pong (Ban Maung) on the Upper Me Yom in Siam (unpublished Ms.), in the Malay Peninsula (Kuala Lumpur) as well as on the Andaman Islands.

P. campanulata is closely related to two other Burmese species. One of these, *P. meridiana*, has been found as yet only in eastern and northern Burma (except for one record from the Bahamas, obviously the result of accidental transportation), but the other, *P. houlleti*, is even more widely distributed than *campanulata*.

The *campanulata* range is slightly larger than that of *anomala* due to the fact that the line begins at Victoria Point at the southernmost extremity of Burma and passes north through Siam further east than in the case of *anomala*. If " eng " and " Anzahl " are not too strictly interpreted— *campanulata* appears to possess both of Michaelsen's qualifications for endemicity. The species seems to be equally adapted to the varied habitats of the plains and hills except for that of the semi-arid zone of Central Burma in which it has not yet been found.

The only Indian localities (both in Darjiling district) are about as far from the northern border of the *campanulata* area as Kuala Lumpur is from the southern border. The Indian and Malay Peninsula as well as the Andaman Islands records, at present, appear to be the result of accidental transference. As in the case of *anomala* the western border of the *campanulata* area is close to the political boundary of India and probably will have to be moved over into India. The elevations at which the Darjiling district worms were secured unfortunately are unknown.

P. houlleti. This species is widely spread throughout the province of Burma, having been collected in 33 of the 40 districts. It is found on the plains and hills, and on the plateau up to an elevation of 5,000+ feet and most probably is present in the 7 districts which have not yet been investigated. It is known from several localities in Siam (Bawti, Not Theinko, Bangkok in the south ; Chiengmai and Muang Pong in the north), the Malay Peninsula (Kuala Lumpur, Aring in Kelantan, Singapore) and the Andaman Islands. Michaelsen (1900, p. 273) includes Cochin China in the list of localities but I have been unable to trace this record. The species is not known from China (previous records are the result of erroneous suppression of valid species) except for one record from Yunnan just across the Burmese border (Mong Lem State).

In India the species is widely spread and here also has been found in hills and plains and about equally in both. In the hills the species has been found up to an elevation of 4,500 feet but seems to be quite rare or lacking in most parts of the Himalayas, especially at those, higher elevations from which *diffringens* has been obtained. Rawalpindi is the northernmost locality, Dehra Dun and Bhim Tal the next.

Beyond the mainland of Asia the species has been reported from Sumatra (twice), Java (twice), the Philippine Islands (twice), Fiji Islands, Ceylon, Madagascar, Gross Comoro and French Guiana. None of these records can be accepted until verified because of a long confusion of *houlleti* with at least three other species. In view of the ability of the species to maintain itself successfully in a wide range of habitats varying from the equatorial rain forest to the monsoon plains and semi-desert lowland regions as well as the hills, its wide distribution throughout India and southeastern Asia, it is very curious that the species has not been transported as widely as *diffringens.*

P. houlleti is close to two other Burmese species, *P. campanulata* (Burmese-Siamese), and *P. meridiana* (eastern and northern Burma). The species is considered to have originated somewhere in the Burmese-Siamese region but just how much of its Indian distribution, if any, is to be attributed to accidental transportation is not clear. The Ceylon and Andaman Islands records are regarded as due to accidental carriage.

P. planata. This species is rather widely spread in Burma, having been found in 22 of the 40 districts. Within the semi-arid region of Central Burma it has been found but once (Pyinmana) and is known from only three localities on the Shan Plateau (Namkham, Lashio, Karen Hills of Toungoo district) where it has been found at elevations of 2,000+ to 3,000+feet. Although widely spread it is not common, usually being found only after careful search and then not in numbers. It is not known from Siam and China but has been found once in the Malay Peninsula (Kuala Lumpur) and apparently is rather common on the Andaman Islands. *P. planata* is close to a trans-Salween species, *P. immerita,* known only from Kengtung, Mang Lun and Pang Long States, an area quite definitely to be characterized as " eng begrenzten ".

The only Indian record is Katlicherra (South Cachar in Assam) which is perhaps 150 miles from the nearest Burmese locality (Upper Chindwin district). Very little is known of the earthworm fauna of the

intervening region but there is no reason to suppose that *planata* is lacking therein. A line drawn from the northern portion of Mergui district north through Burma to Lashio, Namkham, and Myitkyina and then through Cachar to Akyab marks off the range of the species as now known and encloses an area somewhat smaller than that of *anomala* (but west of the *immerita* area). *P. planata* appears, at present to be primarily a Burmese species that has been accidentally transported to the Malay Peninsula and the Andaman Islands. However, it is possible if not probable that the species will be found to be fairly widely spread in Assam and Siam and perhaps also throughout the Malay Peninsula.

P. posthuma. This species is rather widely spread through the province of Burma, having been collected in 29 of the 40 districts, but is restricted to the plains and low country. Even here it is found most commonly and in greatest numbers in the sandy soil along the banks of rivers and streams. Two records from the Shan Plateau are erroneous. If found in the higher hills and on the Plateau, the localities probably will be along banks of streams. The species is known from the Andaman Islands and has been recorded once from the Malay Peninsula (no specific locality) by Beddard but the record has never been confirmed and Stephenson was unable to find Beddard's specimens in the British Museum. The species has been collected at several localities in Upper Siam (Chiengmai 1,000 ft., Ban Sa-iep and Mu'ang Pong) as well as in lower Siam (Bangkok) but is unknown from China.

According to Stephenson (1923, p. 311) *P. posthuma* is " universally found in North India " but though it has been collected from a number of localities it has never been reported from the higher mountain elevations at which *diffringens* has been found. The northernmost localities are in the Punjab. Furthermore, the species has been found hitherto only once south of a line from Baroda to Calcutta and then at Bombay. Of the Indian localities, almost all are in the plains or lowlands. Five times only has the species been reported from places with an elevation greater than a thousand feet (Hoshiarpur, 1,000+feet, ; Kalka, 2,000-3,000 ft. ; Ajmere and Udaipur, 1,500-2,000 ; Dehra Dun, 2,000-3,000 ; and even here the elevations at which the worms were secured may be unknown). Eighteen of the Indian localities are shown even on our small maps as being on the banks of rivers.

Morphologically as well as physiologically (adaptation to the sandy river-bank habitat) *P. posthuma* is rather peculiar and unlike all other Burmese species of *Pheretima*. For this reason a Burmese origin for the species at first seems to be rather doubtful. However, the more important of the morphological peculiarities have to do with the commissural blood vessels of segments x and xi and these characteristics also distinguish the species from all other Pheretimas, at least so far as is known at present. The Burmese distribution though extensive is much less so than that of *Pontoscolex corethrurus* which is certainly an introduced species but not so restricted as to habitat. For the present *P. posthuma* may be regarded, though doubtfully, as of Burmese or Burmese-Siamese origin and with a south-eastern Asiatic mainland distribution that does not require the assumption of accidental transference at least by man.

II.

P. diffringens. In Burma this species has been found on the Shan Plateau (Namkhai, Namkham, Lashio, Maymyo, Mogok, Taungyi, Htamsang, Kalaw, Manchio and Thandaung) and outside the plateau only once, at Bhamo. It has been found at elevations of 2,000+to 4,000+feet and only once below 2,000 feet, and then at Bhamo (under 500 feet but north of the tropic of Cancer). The species is known from several provinces of China (Yunnan, Szechuan, Kiangsu, Kiangsi, Chekiang, Anhwei and Fukien) and is close to Chinese, Korean and Japanese species which are not at present clearly distinguished and which may have to be suppressed. Unknown from Siam, French Indo-China, the Malay Peninsula or the Andaman Islands.

In spite of the fact that Stephenson gives the distribution of the species as " Throughout India " (1923, p. 304), *diffringens* has been found hitherto only in a region north of a slightly curved line drawn from Lahore south-east to Rangamati, and in South India where it is known only from the Bababudan, Nilgiri and Palni Hills. *P. diffringens* has been found in the eastern and western Himalayas and Assam at elevations of 3,000-7,000 feet, in the North-west Frontier Province at elevations of 1,000-2,000 feet, and in South India at elevations of 4,500-7,500+feet.[1] At lower elevations the species is known only from the Punjab (600+feet), Siliguri, Teesta Bridge (500-700 ft.) and Rangamati in Bengal, Kobo and Sadiya in Assam. The Kangra district localities (Punjab) are at the edge of hills north-east of Lahore, Siliguri and Teesta Bridge are close to the Himalayas as are Kobo and Sadiya while Rangamati is close to the hills of the Chittagong Hill Tracts. Rangamati is the only plains record south of the tropic of Cancer (the Rangamati worms may of course have been obtained at some nameless locality in hills near Rangamati), all of the other plains and lower hills records quite to the north of that tropic.

P. diffringens is widely spread as a result of accidental transportation, probably much more widely spread than any other species of *Pheretima*. Much of this accidental carriage is certainly due to man,—note the records from botanical gardens and hot houses in Europe, America and elsewhere. It is extremely unlikely that this species has been carried by man, in India for example, only to temperate zone localities or only to those high hills in the tropics with a cool climate. We must assume therefore, that in tropical lowland localities to which the species has been transported, it has been unable to maintain itself though able to adapt itself to a variety of habitats in the temperate zone and higher hills of the tropics. These considerations together with the wide Chinese distribution seem to indicate that the worm is a temperate zone form and that it has originated somewhere in the Chinese region. Penetration into Burma and at least into the eastern portion

[1] The elevations at which *P. diffringens* has been secured in South India are as follows :—Kodaikanal, 7,000, 6,850, 6,900, 6,850-7,000 ft. ; Kotagiri, 5,700 ; Fern Hill, 7,500 ; Bababudan Hills (Kadur district in Mysore), 4,500 ; Naduvatam, 6,000 ; Coonoor, *ca.* 5,000 ; Benhope, exact elevation not known but nearest railway station, Hillgrove, is *ca.* 3,000 ft. The writer is indebted to Dr. S. L. Hora for much of this information.

of north India accordingly is to be regarded as due to natural migration of the species, while accidental transportation must be invoked to explain its presence in South India. Whether the presence of *diffringens* in north India way into the North-West Frontier Province can be regarded as brought about without accidental transportation is not yet clear.

P. hawayana. In Burma this species has been found on the Shan Plateau and only on the northern portion (Namkham, Kawngmu, Kutkai, Lashio and Mogok, all north of 22° latitude). It has been found only at elevations of 2,000 to 3,000+feet. The species is known from several provinces of China (Yunnan, Szechuan, Fukien and Chekiang) and may have been described from Japan under another name. Stephenson has recorded the species from the Malay Peninsula (Kuala Lumpur and Singapore), records which cannot be accepted until verified because of a failure to distinguish between *hawayana* and *morrisi.*

In spite of the fact that Stephenson calls this species " one of the commonest worms in India " (1923, p. 302), it is known at present only from a few localities ; Lahore (Punjab), Ramnee (Western Himalayas), Kurseong (Eastern Himalayas) and Shillong (Assam). All of these localities are north of 25° latitude and the westernmost are north of 30°. All Indian records are from elevations of 3,000 to 5,000+feet. The Ceylon records are also from the hills.

With a distribution like that of *diffringens* and an apparently similar temperature restriction (barrier) it is probable that *hawayana* likewise originated in China. Presumably it has penetrated into Burma and at least the eastern portion of north India by its own activity.

P. morrisi. This species is more widely spread in Burma than *hawayana*, having been found not only on the Shan Plateau (Namkham, Kutkai, Hsenwi, Lashio, Mogok, Maymyo, Taungyi, Htamsang, Pang Long, Mang Lun, Mong Yai and Kengtung States) but also in Myingyan (Mt. Popa only), Bhamo and Myitkyina districts. It has been found only at elevations of 2,000 to 4,000 feet, except at Myitkyina and Bhamo (under 500 feet but north of the tropic of Cancer). The species is known from four provinces of China (Szechuan, Fukien, Chekiang and Yunnan). It has been collected once in Siam (Chiengmai, 1,000 feet) but is unknown from the Malay Peninsula and French Indo-China. (A record of *P. hawayana* from the Malay Peninsula by Stephenson may actually be for *morrisi* which is known from Penang.)

In India *morrisi* has been found chiefly at elevations of 2,000 to 6,500 feet. It has been obtained at only three localities south of the Lahore-Rangamati line ; Brindaban, Udaipur (2,460 feet) in Rajputana, and Bombay. Only three records are from lowlands ; Lahore (600+feet), Brindaban (500-feet), and Bombay.

With a distribution like that of *diffringens* and *hawayana* and an apparently similar temperature barrier, it is possible that *morrisi* likewise originated in China and like the other two species has penetrated into northern Burma and at least the eastern portion of north India by its own activity. Its presence on Mt. Popa in Burma and those localities in India south of the Lahore-Rangamati line is regarded as due to accidental transportation.

P. robusta. In Burma this species has been found only in the northern portion of the Shan Plateau (Namkham, Kutkai, Lashio, Hsipaw and Pang Long States) where it has been found at elevations of 2,000+to 4,000+ft. The species is probably widely distributed in China and has been recorded from the provinces of Yunnan, Szechuan, Fukien, Kiangsu, Kiangsi, Chekiang and Hupei.

Outside the Asiatic mainland the species has been reported from Madagascar, Mauritius, the West Indies and the Philippines. None of these records have ever been confirmed and some of them must be regarded as very dubious.

The only Indian record is that of *P. himalayana* from Darjiling at an elevation of 7,000 feet.

At present it is necessary to regard *P. robusta* as having originated somewhere in China and also as a temperate zone form, that has been able to penetrate into Burma and India as a result of its own activity.

III.

P. elongata. This species is rather widely distributed in Burma having been collected in 20 of the political districts. It has been found both in the plains (monsoon and semi-arid) and hills and in the latter to a height of 3,000 feet but has been obtained from only four localities north of the tropic of Cancer; Mawlaik, Indaw Lake, Bhamo and Myitkyina. Although fairly widely spread it is not common and when found is usually not obtained in any considerable numbers unless the soil is " black ". It has been collected in Siam (Bangkok and Chiengmai) and the Andaman Islands but is unknown from the Malay Peninsula, French Indo-China and China.

In India the species is almost confined to the tropical portion as it has been found only once north of the tropic of Cancer, and then at Karachi.

P. elongata has been transported widely throughout the tropics and presumably by man. Only in Burma and at Karachi has the species been found outside of the tropics and then not far to the north. It is unlikely that a species so widely spread by external agencies has been carried only into tropical regions. Restriction to the tropics with the correlated inability to maintain itself in cooler regions to which it must have been carried seems to require a tropical origin for the species. Morphologically *elongata* can be included in Michaelsen's subgenus *Polypheretima* from the southern portion of the Malay Peninsula, Borneo, Celebes and New Guinea and in fact is so close to one of the Borneo species, *P. stelleri,* that the two cannot be adequately distinguished, at least at present. Should the original home of *elongata* be in Borneo, the Burmese and Indian records are to be considered the result of artificial transference. Even though the home of the species should prove to be in the Malay Peninsula the (present) Indian distribution will still have to be explained as the result of accidental transportation.

P. bicincta and *P. taprobanae.* Neither of these species has been found in Burma and at present there is little of importance to be said with regard to the distribution of these worms. *P. bicincta* has been recorded only twice from the " *Pheretima* domain " ; once from the Philippines and once from Java. Its presence in India is obviously the

result of accidental transportation. *P. taprobanae* is quite unknown from the "*Pheretima* domain", and also must have been carried into India accidentally. All localities at which these two species have been found are within the tropics. Like *elongata*, *bicincta* and *taprobanae* appear to have had a tropical origin and to be able to maintain themselves only in that portion of the world.

To summarize.—Of the thirteen Indian species of *Pheretima*, three quite obviously are present in India as the result of accidental transportation. The original homes of these species are unknown but one is to be sought for in Borneo and the probability is that all three are tropical if not primarily equatorial. Four species are regarded as originally Chinese, *e.g.*, *diffringens*, *hawayana*, *morrisi* and *robusta*. Of the remaining species, *alexandri*, *anomala*, *campanulata* and *planata* (possibly also *houlleti* and *posthuma*) are regarded as primarily Burmese or Burmese-Siamese. Each species in the last two groups (Chinese and Burmese) is in India, or will eventually be shown to be, as a result of its own activity rather than as the result of accidental carriage. Immigration of Chinese species from the north-east (and north ?) and of Burmese species from the east explains the heavy concentration of *Pheretima* localities in that portion of India north of a line from Baroda to Calcutta. Some species however have been carried accidentally to isolated localities which may be at considerable distances from regions to which the species have penetrated naturally.

South-eastern Asia- -India-Burma-Siam-French-Indo-China—lacks the physical features such as deserts, snow-covered mountain ranges and salt seas that are usually regarded as effective barriers to earthworm migrations. This region does have a wide variety of climatic, edaphic and physiographic habitats. One species, *P. posthuma*, is restricted largely to one peculiar habitat, the sandy soil of river banks. Another species, *P. campanulata*, at present, seems to be unable to exist in the semi-arid region of central Burma. Other species however are able to adjust themselves to and maintain themselves in a wide variety of the habitats available. Within the region the only effective barrier to migration seems therefore to be that of temperature. But temperature cannot be invoked to explain the boundaries of natural areas of certain species, or why a particular species is lacking in a contiguous region of suitable habitats. Of those factors which are of most importance in explanation of this problem, factors such as speed of travel and time available for migration since origin of the species, we have no knowledge whatever.

On a previous page a prophecy has been hazarded that few further species of *Pheretima* will be found in India, barring of course importations of an accidental nature. If found, further species will be collected in the Himalayas to the north and in Assam and Chittagong on the east. Of the Chinese species perhaps the most likely to be found is *P. californica* which may be anticipated in the hills and mountains to the north. Of the Burmese species the most likely immigrants to be found in Assam are *austrina*, *choprai*, *exigua*, *birmanica*, *peguana* and some of the *doliaria* group. In Bengal (Chittagong) the most likely immigrant is *P. peguana*. Burmese species are not to be expected in the Himalayas,

at least at the higher elevations at which *diffringens* and other Chinese species are obtained.

HABITS.

In an attempt to " determine the significance " of the enteronephric excretory organs of earthworms, Bahl (1934) has discussed the " Habits of *Pheretima* as compared with those of *Eutyphoeus* ". Nowhere in the text of the paper is there any indication of the number or names of the species studied, though two names, *P. posthuma* and *E. waltoni*, are mentioned in labels of figures. Failure to observe an elementary precaution in scientific work has resulted in statements such as " the castings of *Pheretima always* consist of solid rounded pellets " (italics mine). Actually, *P. posthuma* is the only species of the genus that is known to produce pellet-like castings. The castings of all other species of *Pheretima*, so far as is known, are of the tower-like type that Bahl imputes only to *Eutyphoeus*. Furthermore, *P. posthuma* is the only species of the genus that is restricted to the river-bank habitat.

SYSTEMATICS.

Genus: **Pheretima** Kinberg.

1867. *Amyntas* (Type, *A. aeruginosus, non* Wollaston 1865), + *Nitocris* (Type *N. gracilis, non* H. & A. Adams 1854.) + *Pheretima* (With two species, *P. montana* and *P. californica.*) + *Rhodopis* (Type, *R. javanica, non* Reichenbach 1854.) + *Perichaeta*, Kinberg, *Ofv. Ak. Forh.* XXIII, pp. 101, 102.
1883. *Megascolex* (maximum part) + *Perichaeta* (minimum part) Beddard, *Ann. Mag. Nat. Hist.* (5), XII, p. 214.
1884. *Perichaeta* (part), Beddard, *Ann. Mag. Nat. Hist.* (5), XIII, p. 401.
1888. *Perichaeta* (maximum part) + *Megascolex* (minimum part), Rosa, *Ann. Mus. Genova*, XXVI, p. 155.
1889. *Megascolex* (part), Vaillant, *Hist. Nat. Annel.* III, (1), p. .
1890. *Perichaeta* subgenus *Perichaeta*, Beddard, *Proc. Zool. Soc. London*, 1890, p. 56.
1895. *Perichaeta* (part, excluding *Lampito* and probably also *P. viridis* Schmarda 1861) + *Megascolex* (part, including *M. margaritaceus*, *M. iris* and *M. pictus*), Beddard, *Monog.* pp. 388 and 370.
1899. *Amyntas*, Michaelsen, *Mitt. Mus. Hamburg*, XVI, p. 3.
1900. *Pheretima* (part, excluding *P. burliarensis* and *P. lawsoni*), Michaelsen, *Das Tierreich*, X, p. 234.
1900. *Amyntas*, Beddard, *Proc. Zool. Soc. London*, 1900, p. 613.
1907. *Pheretima*, Michaelsen, in Michaelsen and Hartmeyer, *Fauna Sudwestaustraliens*, I, p. 164. (*P. montana* designated type species.)
1922. *Promegascolex*, Cognetti, *Boll. Mus. Zool. Torino*, XXXVII, (744), p. 3. (Type, *P. mekongianus.*)
1923. *Pheretima* (part), Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 288, (excluding *P. burliarensis.*)
1928. *Pheretima*, Michaelsen, *Ark. Zool.*, XX, A, (3), p. 4.
1930. *Megascolex* (part, including only *M. mekongianus*) + *Pheretima*, Stephenson. *The Oligochaeta*, pp. 837 and 838.
1934. *Pheretima*, Michaelsen, *Quart. J. Mic. Sci.* LXXVII, p. 12. (*P. californica* designated as type species in place of *P. montana.*)

Diagnosis. Setae perichaetine. One gizzard in viii[1]. Excretory organs exonephric and enteronephric micronephridia. Testes and male funnels in testis sacs. Prostates racemose.

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[1] Although the gizzard is in viii, in all species in which septum 8/9 is present, one or more of septa 8/9-10/11 may be lacking or rudimentary so that the gizzard has the appearance of extending posteriorly.

A large proportion of the species of *Pheretima* are characterized as follows. The setae begin on ii on which segment there is a complete setal circle. The clitellum is annular, extending from 13/14 to 16/17; with development of the clitellar glandularity the setae of the clitellar segments drop out and are not replaced, the intersegmental furrows between xiv and xv, and xv and xvi disappear and the dorsal pores on 14/15 and 15/16 are occluded. Ventral reproductive apertures; the spermathecal and male pores symmetrically paired, a single female pore. Septa 8/9-9/10 lacking, rudimentary or not normal. The intestine begins in xv or xvi close to 15/16. The last pair of hearts is in xiii, all hearts of ix-xiii opening into the ventral blood vessel. Seminal vesicles are paired in xi and xii, the vesicles of xi excluded from the testis sac or sacs. Spermathecal diverticulum passing into the duct just at, close to or within the parietes. Only constant specific deviation from any of these characteristics requires especial mention in the diagnoses.

Within a species there may be variation with regard to certain characteristics. Thus the single female pore may be replaced by paired female pores. One or more of the anteriormost dorsal pores may fail to develop. An occasional specimen may have an unusually large or an unusually small number of setae on one or more segments. Normally paired testis sacs may be replaced by unpaired testis sacs and *vice versâ*. A genital marking may be lacking or extra genital markings may be present. One or more of the spermathecae, ovaries, prostates, etc., may be lacking or one or more extra spermathecae, prostates, ovaries, etc., may be present. When the specific norm or pattern is known it is scarcely necessary to include such variations in a diagnosis of the species. Unfortunately, in several forms, as *P. taprobanae* and *bicincta*, only a very few specimens have been studied and hence little is known as to the variation of important structures or characteristics. Even in some of the older species, as *P. elongata* (E. Perrier) 1872, the specific norm is as yet scarcely obvious in all its details. In certain species, abnormal individuals may be much more common than normal individuals. Some of these species are known, even today, only from the aberrant specimens, though none of these species are Indian. Even though abnormal individuals are more common than normal worms, a diagnosis must of course describe only the normal forms. A correct definition based on normal individuals has only recently been possible for one Indian species, *P. anomala* (*vide* p. 193).

Descriptive and diagnostic terms and conventions. Intersegmental furrow is used in a definitely restricted sense so as to refer only to the slight line constituting the boundary externally between two successive segments. By this limitation of meaning a much more definite characterization of the location of the spermathecal pores is possible. The intersegmental furrow as now defined must be distinguished from the deep circular groove often present between adjacent metameres on strongly contracted specimens. The intersegmental furrow lies at the bottom of such a groove. Actually the intersegmental furrow, as now defined, is not a furrow at all but a new term is perhaps unnecessary.

Important information with regard to setal numbers is shown by a setal formula such as the following: vi/13-17, xvii/20-27, xviii/10-15, xix/20-27, 56-64/xx. The first portion of this formula shows that on segment vi there are 13-17 setae ventrally between two longitudinal lines passing across the spermathecal apertures parallel to the midventral line. These setae are called spermathecal setae. Ventral setae on xviii between the male pores are called male setae. The formula indicates that the number varies from 10 to 15. Similarly there are 20-27 male setae on xvii and xix but in this case the figures show the number of setae between longitudinal lines passing across the male pores parallel to the midventral line when the pores are superficial or across the centres of the apertures of the invaginations if the male pores are invaginate. If the spermathecal pores are large or invaginate the spermathecal pore lines also pass across the centres of the apertures. The portions of a formula with segmental numbers (in Roman numerals) as denominators indicate the total number of setae on the segments mentioned, thus 56-64/xx shows that the number of setae in the circle on xx varies from 56 to 64. It is sometimes necessary to refer to a definite seta or intersetal interval and in such references italicized small letters are used, thus *a* refers to the first seta on either side of the midventral line, *b* to the second, *c* to third, etc. Dorsally the first seta on either side of the middorsal line is called *z*, the second *y*, the third *x*, etc. A male pore may be located as in line with seta *b* while a dorsal spermathecal pore may be in line with *y*. The setal nomenclature is most useful however in connection with indication of location of genital markings. Thus a genital marking may be said to be in *ab* which does not necessarily mean that the marking is actually between *a* and *b* but in the space between two lines passing across setae *a* and *b* parallel to the midventral line, the exact location of the marking indicated by qualifying terms such as pre- or postsetal or intersegmental.

Superficial and invaginate, in connection with the genital markings scarcely require explanation. An invagination containing a genital pore may be restricted to the body wall or conspicuously protuberant into the coelomic cavity, in the latter case, if associated with the male genital terminalia, a pouch formed by the invagination is called a copulatory chamber.

Spermathecal apertures may be minute as in *diffringens* or large as in *indica,* minute pores may be superficial or invaginate, a large pore, apparently always, superficial. A large primary spermathecal aperture (superficial) must not be confused with the secondary spermathecal aperture of an invagination containing the primary spermathecal pore.

Genital markings are special areas that develop in the epidermis of certain segments of an anterior portion of the body towards sexual maturity. Like the male and spermathecal pores the markings may be either superficial or invaginate. If invaginate the markings are usually within copulatory chambers of male or spermathecal pore invaginations but may be located, as in *P. anomala,* in special invaginations that are eversible. The markings are usually associated with definite, glandular masses which may be sessile on or within the body-

wall, or stalked and either buried in the muscular layers or protuberant into the coelomic cavity.

Length, diameter, and number of segments are usually mentioned in specific descriptions and diagnoses. There has however been considerable carelessness in connection with these characteristics. It should be obvious that segmental enumerations and measurements of juvenile, immature, autotomized, regenerating or regenerated specimens have no particular value so far as specific characterization is concerned. Measurements for the sake of uniformity should be made on preserved, contracted specimens. (The best method of killing worms for taxonomic study is to merely drop the specimen into commercial methylated spirit. Worms may be hardened in 10 per cent. formalin and then preserved in formalin or alcohol.) The diameter may be measured at the region of greatest thickness, usually in or near the clitellar region.

Simple, as applied to intestinal caeca, is used to characterize an anteriorly directed, more or less finger-shaped evagination of the gut that has but one main axis. The term is used even though there may be several short, secondary outgrowths from the dorsal or ventral margins of the caecum.

A seminal vesicle is an outgrowth from a septum, first appearing, at least in many species, as an ovoidal vesicle or ampulla attached by a ventral stalk to the posterior face of a septum, either 10/11 or 11/12. With further development the stalk broadens out into a softish, ventral lamina with which the smaller dorsal ampulla may become fused so as to be no longer recognizable, or the dorsal ampulla may be definitely constricted off from the ventral lamina and of a distinct texture and shade. Seminal vesicles may be free or (in segment xi only) included within the testis sac or sacs. "Included" in association with testis sacs in the specific diagnoses has reference only to the anterior pair of seminal vesicles. Exclusion of these vesicles, as a negative characteristic, is not mentioned in the diagnoses.

Testis sacs are thin-walled, membraneous sacs enclosing the testes and male funnels. The testis sacs may be paired or unpaired. If paired each sac contains only one testis and one male funnel. If unpaired, each sac contains the two testes and two male funnels of a segment. Paired sacs may be ventral and suboesophageal or vertical, *i.e.*, extending dorsally at the sides of the gut. The seminal vesicles of xi may be included within paired, vertical sacs but are never included within paired or unpaired suboesophageal sacs. Unpaired sacs may be ventral and suboesophageal or U-shaped, horseshoe-shaped, annular or cylindrical. When the sacs are U-shaped or horseshoe-shaped the limbs of the sac extend dorsally or ventrally at the sides of the gut. An annular sac surrounds the gut completely and is formed by the dorsal or ventral union of the limbs of a U-shaped or horseshoe-shaped sac. A cylindrical sac is formed by a sheet of tissue in form of a cylinder passing anteroposteriorly between two successive septa in such a way as to enclose practically all of the organs of a segment. If the testis sac of xi is cylindrical the seminal vesicles of that segment are always

included therein. If the sac is U-shaped the vesicles may or may not be included.

Miscellaneous notes.—Identification internally of certain anterior segments has occasionally, from Bourne to Bahl, proved troublesome, as a result of the loss of certain septa and the dislocation or delicacy of some of those present. The female pores in *Pheretima* are always (except on very rare, abnormal specimens) on xiv and the ovaries are always one segment in front, in xiii. Having determined that the specimen is normal by reason of the location of the female pores on xiv, the ovaries can then be located in the opened specimen and from the ovarian segment which is readily identified the anterior segmentation can be worked out, checking lost septa against segmental commissures of the circulatory system (hearts) or in case of loss of hearts against segmental nerves or the setal circles which are visible on the coelomic face of the parietes. Spermathecae can be used as indicators only after it has been determined whether the ducts pass into the parietes anteriorly or posteriorly. Failure to observe this simple precaution has resulted in mistaken enumeration of the first post-gizzard septum in *P. posthuma.*

The worm should be dissected through a mid-dorsal incision. This mode of dissection most often enables determination of important characteristics without damage to structures that may require to be kept intact for future reference.

Key to Indian species of *Pheretima.*

For the sake of greater convenience this key has been based so far as is possible on external characteristics.

1.	*a.* Multithecal	*P. elongata.*
	b. Not multithecal	2.
2.	*a.* Bithecal	*P. taprobanae.*
	b. Quadrithecal to decithecal	3.
3.	*a.* Quadrithecal	4.
	b. Sexthecal to decithecal	6.
4.	*a.* Male pores superficial	5.
	b. Male pores invaginate, in copulatory chambers .	*P. planata.*
5.	*a.* Spermathecal pores on 5/6-6/7	*P. morrisi.*
	b. Spermathecal pores on 7/8-8/9	*P. robusta.*
6.	*a.* Sexthecal	7.
	b. Octothecal to decithecal	10.
7.	*a.* Spermathecal pores on 5/6-7/8	8.
	b. Spermathecal pores on 6/7-8/9	9.
8.	*a.* Male pores on xx, genital markings invaginate .	*P. anomala.*
	b. Male pores on xviii, genital markings superficial.	*P. hawayana.*
9.	*a.* First dorsal pore on or anterior to 10/11, one stalked gland to each spermathecal invagination	*P. houlleti.*
	b. First dorsal pore on or posterior to 11/12, two stalked glands to each spermathecal invagination	*P. campanulata.*
10.	*a.* Octothecal	11.
	b. Decithecal	*P. bicincta.*

11. *a*. Spermathecal pores segmental, male pores invaginate, genital markings in the setal circles .	*P. posthuma*.
b. Spermathecal pores intersegmental, male pores superficial, genital markings not in the setal circles	12.
12. *a*. Preclitellar genital markings present, seminal vesicles excluded	*P. diffringens*.
b. Preclitellar genital markings lacking, seminal vesicles included	*P. alexandri*.

ABNORMAL FORMS.

Abnormal forms, in particular localities or in certain species, may be as common as or even much more common than normal forms. One unacquainted with the normal forms and having only abnormal individuals may have considerable difficulty in identification. A key is therefore given to assist in placing the more commonly found abnormal forms.

1. *a*. Athecal	2.
b. Thecal	9.
2. *a*. Male pores present	3.
b. Male pores lacking	7.
3. *a*. Male pores superficial	*P. alexandri*.
b. Male pores invaginate	4.
4. *a*. Male pores in parietal invaginations . . .	5.
b. Male pores in copulatory chambers . . .	6.
5. *a*. Male pores on xviii, genital markings superficial.	*P. elongata*.
b. Male pores on xx, genital markings invaginate .	*P. anomala*.
6. *a*. First dorsal pore on 11/12 or posteriorly . .	*P. campanulata*.
b. First dorsal pore on 10/11 or anteriorly . .	*P. houlleti*.
7. *a*. First dorsal pore on 12/13, seminal vesicles included	*P. alexandri*.
b. First dorsal pore on 11/12 or anteriorly, seminal vesicles excluded	8.
8. *a*. First dorsal pore on 11/12	*P. campanulata*.
b. First dorsal pore on 10/11 or anteriorly . .	*P. houlleti*.
9. *a*. Spermathecal pores superficial, occasionally in groups of 2-4	*P. elongata*.
b. Spermathecal pores invaginate, never grouped .	10.
10. *a*. Male pores lacking	*P. anomala*.
b. Male pores present	11.
11. *a*. Male pores on xix-xxi	*P. anomala*.
b. Male pores on xviii	4.

Pheretima alexandri (Beddard.).

1900. *Amyntas alexandri*, Beddard, *Proc. Zool. Soc. London*, 1900, p. 998. (Type locality, Calcutta. Type in the British Museum.)
1903. *Pheretima Alexandri*, Michaelsen, *Geogr. Verbr. Berlin*, p. 94.
1909. *Pheretima alexandri*, Michaelsen, *Mem. Ind. Mus.* I, p. 109.
1910. *Pheretima Alexandri*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), p. 11.
1914. *Pheretima lignicola*, Stephenson, *Rec. Ind. Mus.* VIII, p. 399. (Type locality, Dibrugarh, Assam. Type in the Indian Museum.)
1915. *Pheretima lignicola*, Stephenson, *Mem. Ind. Mus.* VI, p. 99.
1920. *Pheretima lignicola*, Stephenson, *Mem. Ind. Mus.* VII, p. 223.
1922. *Pheretima suctoria*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 434.
1923. *Pheretima alexandri* + *P. lignicola* + *P. suctoria* (part. excluding Andaman Island forms), Stephenson, *Oligochaeta*, in *F. B. I. Series*, pp. 291. 305 and 311.

1924. *Pheretima lignicola* + *P. suctoria* var. *mullani*, *Rec. Ind. Mus.* XXVI, p. 340.
1925. *Pheretima suctoria* var. *mullani*, Stephenson, *Proc. Zool. Soc. London*, 1925, p. 893.
1931. *Pheretima alexandri*, Stephenson, *Rec. Ind. Mus.* XXXIII, p. 182. (Redescription of the type.) Also Gates, *Rec. Ind. Mus.* XXXIII, p. 363.

Diagnosis.—Octothecal, spermathecal pores minute and superficial, four pairs, on 5/6-8/9. Male pores minute and superficial. Just anterior and posterior to each male pore a small, greyish, translucent area, usually rather crescent-shaped and with the concave side of the area facing the male pore, the translucent areas and the male pore slightly depressed and surrounded by a narrow, slightly protuberant, U-shaped ridge, the limbs of the U directed midventrally. Setae: vi/6-12, vii/8-14, viii/10-16, xvii/13-21, xviii/10-18, xix/14-21, 13-20/ii, 18-24/iii, 40-50/viii, 50-60/xii, 61-71/xx. First dorsal pore on 12/13. Length 105-200 mm. Diameter 4-8 mm. Segments 90-133.

Intestinal caeca simple. Testis sacs paired, ventral in x, vertical in xi; seminal vesicles included. Spermathecal duct bulbous, muscular, lumen in ental portion of the duct large and communicating with the narrowed lumen in the ectal portion through a minute pore on the bluntly rounded tip of a rather conical papilla; diverticulum with slender but muscular stalk and a looped, elongately tubular seminal chamber.

Distribution.—Bombay, Calcutta and Dibrugarh in Assam. Outside of India; Burma, China (Yunnan), Siam and the Andaman Islands.

Pheretima anomala Michaelsen.

1907. *Pheretima anomala*, Michaelsen, *Mitt. Mus. Hamburg*, XXIV, p. 167. (Type locality, Calcutta. Types in the Indian and Hamburg Museums).
1909. *Pheretima anomala*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 189.
1910. *Pheretima anomala*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), p. 11.
1923. *Pheretima anomala*, Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 294.
1933. *Pheretima anomala*, Gates, *Rec. Ind. Mus.* XXXV, p. 496.

Material examined.—From the Indian Museum.—1 macerated, clitellate specimen labelled, " On the hill sides near Pashok Bungalow. Dr. S. L. Hora.", 33 aclitellate and 19 clitellate specimens labelled, " Forest Rest House, Lachhiwala, Dehra Dun District. 29. ix-3. x. 35. Dr. S. L. Hora.", and 1 clitellate specimen labelled, " Dehra Dun. 12. x. 35. Dr. S. L. Hora.". All of the Dehra Dun specimens are softened.

The Dehra Dun specimen and all except two of the Lachhiwala specimens are athecal (= *forma typica* of Stephenson, 1929). Each of the two exceptional specimens, one clitellate and one aclitellate, has a single spermathecal pore, on 5/6, on the right side. The spermathecae are normal but there is no spermatozoal iridescence in the seminal chambers.

Diagnosis.—Sexthecal, spermathecal pores minute and invaginate, each pore at the centre of a vertically placed, elliptical marking on the anterior wall of an invagination with a transversely slit-like aperture; three pairs, on 5/6-7/8. Male pores minute and invaginate, each pore at the centre of a transversely elliptical tubercle on the roof of a slight parietal invagination in the setal circle of xx. Genital markings internal, each marking on the roof of a slight parietal invagination

with a transversely slit-like aperture; three pairs, in the setal circles of xvii-xix. Setae present ventrally on xvi: vi/17-22, vii/17-23, xix/16-18, xx/15-21, 60-68/iii, 90-96/viii, 87-95/xii, 81-90/xiii, 6-26/xvi, 61-70/xx. First dorsal pore on 12/13. Length 80-180 mm. Diameter 4-5½ mm. Segments 119-30.

Intestinal caeca simple. Testis sacs unpaired and ventral. Spermathecal diverticulum with short stalk, looped middle portion in which the lumen is gradually widened and a slenderly club-shaped seminal chamber. Genital marking glands mushroom-shaped, the duct muscular, shortly spindle-shaped and coelomic.

Very few or none of the specimens in a series of *P. anomala* from any particular locality are actually characterized as above. Most of the specimens are quite markedly different. The variations diverge in two different directions with a large proportion of the variant forms attaining the extreme of divergence in one direction or the other. One extreme (= *forma typica* of Stephenson, 1929) is distinguished from the forms defined above as follows: genital markings on xxi-xxiv, testes and male funnels in (iv) v-ix (xii), no seminal vesicles, no normal testis sacs, no spermathecae, genital marking glands in xxi-xxiv. Intermediates between this extreme and the form defined above have one or more seminal vesicles, more or less normal testis sacs, one or more spermathecae and lack one or more of the genital markings and their glands posterior to xx as well as some of the supernumerary testes and male funnels. The variation in this direction tends towards a reduction or elimination of certain secondary female organs, the spermathecae, and increase in the number of certain male organs, the gonads, deferent duct funnels and copulatory glands. Without spermathecae a worm cannot receive spermatozoa in a copulatory act and such an individual is regarded by Stephenson as a secondarily evolved, dioecious male. There is, however, no evidence (*vide* Gates 1932 and 1933) to show that spermatozoa are ever produced in completely pseudo-masculinized individuals for the testes are always flat discs in an undischarged, juvenile condition. Furthermore, seminal vesicles, the organs in which the spermatozoa mature, are lacking. Although the pseudo-masculinized individuals do not produce mature spermatozoa, they do have, and apparently always, normal ovaries and a functional oviducal apparatus as well as a clitellum for the secretion of a cocoon. Since spermatozoa are not produced the worms cannot function as males even though the male deferent apparatus is present and normal. Although the clitellum is normally developed and ovaries and the oviducal apparatus appear to be functional the worms apparently do not function as females since they cannot receive spermatozoa from another worm during a copulatory act. In these circumstances the pseudo-masculinized individuals can only be regarded as abnormal. Gates (1933, pp. 508-510) has suggested that the pseudo-masculinization is caused by protozoan parasites present in juvenile individuals prior to initiation of development of the secondary reproductive organs. The definition above is accordingly of normal individuals with a full hermaphroditic complement of reproductive structures.

The other extreme of divergence from normality (= *forma insolita* of Stephenson, 1929) is represented by worms characterized as follows:—

male pores, prostates, prostatic ducts, genital markings and their glands lacking. Intermediate forms between this extreme and the normal worms have one or more prostates and one or more genital markings and mushroom-shaped glands. The deviation from normal in this direction consists of a reduction or elimination of the male copulatory organs. Without male pores a worm cannot transfer spermatozoa in a copulatory act and such an individual is regarded by Stephenson as a secondarily evolved, dioecious female. These pseudo-feminized individuals always have normal seminal vesicles, normal testis sacs with discharged testes and matured spermatozoa and are merely prevented from functioning as males by a failure of the male genital terminalia to develop. A similar condition is occasionally found as an abnormality in other Indian species of *Pheretima* (*P. alexandri* and *P. campanulata*) and there is at present no reason for regarding the absence of the male genital terminalia in *P. anomala* as other than an abnormality in spite of the frequency of its occurrence. Gates (1933, pp. 508-510) has suggested that the pseudo-feminization is caused by protozoan parasites present in juvenile individuals prior to the initiation of development of the secondary reproductive organs, the parasites different from those which cause the pseudo-masculinization. Pseudo-feminized individuals can, theoretically, receive spermatozoa in a copulatory act and deposit cocoons containing fertile eggs.

Only completely or almost completely pseudo-masculinized individuals of *P. anomala* have been found hitherto in India.

Distribution.—Pashok (Darjiling district), Eastern Himalayas ; Dehra Dun and Lachhiwala (Dehra Dun district), Western Himalayas ; Calcutta in Bengal. Outside of India : Burma, Siam (Chiengrai), and China (Mong Mong in Yunnan).

Pheretima bicincta (Perrier).

1875. *Perichaeta bicincta*, E. Perrier, *C. R. Ac. Sci. Paris*, LXXXI, p. 1044. (Types in the Paris Museum. Type locality unknown but supposed to be on Luzon or Mindonoro, Philippine Islands.)
1909. *Pheretima violacea*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 188.
1910. *Pheretima bicincta*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), pp. 11 and 84.
1916. *Pheretima bicincta*, Stephenson, *Rec. Ind. Mus.* XII, p. 335.
1923. *Pheretima bicincta*, Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 294.
1929. *Pheretima bicincta*, Aiyer, *Rec. Ind. Mus.* XXXI, p. 15.

Material examined.—From the Indian Museum : 3 clitellate specimens labelled, " *Pheretima bicincta* = *Pheretima violacea* (Bedd.). Hyderabad, Deccan. Col. D. C. Phillot. ZEV 2829/7.".

External characteristics.—Pigmentation is no longer reconizable.

The setae begin on ii, on which segment there is a complete circle, and are small, closely and regularly spaced. The setal formulae are shown below :—

v	vi	vii	viii	xvii	xviii	xix	iii	viii	xii	xx
10	7*	10	9	9	7	10	33	43	44	..
7*	9	10	11	10	8	11	35	45	46	..
6*	7	9	10	8	6	9	31	42	43	42†

* Gaps in setal line in which setal pits or traces of setal pits are visible.
† Including setal pits as setae.

The clitellum is yellowish or reddish brown, annular, extending from 13/14 to just in front of the setae of xvi, not protuberant (level or constricted); intersegmental furrows and dorsal pores lacking, setae present.

There is a pair of female pores (3).

The male pores are minute and superficial, each pore at the tip of a very tiny, rather conical or almost thread-like protuberance from the centre of a small, indistinctly delimited, shortly elliptical, transversely placed, male pore area that scarcely reaches to a presetal or postsetal secondary furrow.

Genital markings are not visible on these specimens, even after removal of the cuticle, nor with brilliant illumination and under the highest magnification of the binocular. Although the markings are not visible, glands are present internally and after noting these glands the sites of the genital markings were re-examined. On the postsetal portion of xviii, in a region just median to the male pore line, on each side, a number of minute pores are just barely visible, but the areas on which these pores are situated do not appear to be different from the surrounding epidermis.

Internal anatomy.—Septum 9/10 is present and muscular (2); 8/9 lacking (2).

The intestine begins in xv (2). The intestinal wall of one specimen is softened and in this worm the caeca were not seen. In the other specimen the caeca are short, anteriorly directed, confined to xxii, two slight incisions of the dorsal margin, 2-3 slight incisions of the ventral margin.

The last pair of hearts is in xii (2). There is a pair of hearts belonging to ix (2). The hearts of x and xi are included within the testis sacs.

The testis sacs are unpaired and horseshoe-shaped, the midventral termini of the sacs separated by a slight space in which is the ventral blood vessel. The dorsal blood vessel, in at least the posterior portions of x and xi, is included within the testis sac. The sac may be constricted in such a way as to form an anteriorly directed mid-dorsal lobe. The ventral ends of the anterior testis sac may be continued anteriorly on the ventral parietes parallel to the nerve cord for a short distance. The anterior vesicles are small and are included within the posterior testis sac. The vesicles of xii are rather small, acinous, vertically placed bodies that reach up into contact with the dorsal blood vessel. The prostates are in xvii-xix. The duct is short, with muscular sheen, bent into a U-shaped loop, the ectal limb much thicker than the ental limb, but narrowed as it passes into the parietes.

The spermathecae are small, the ampulla only slightly wider than the duct, shortly ovoidal, ellipsoidal or heart-shaped, and distinguished from the duct by a translucent appearance. The duct, including the portion within the parietes, is a trifle longer than the ampulla. The diverticulum which passes into the anterior face of the duct at the parietes is shorter than the combined lengths of duct and ampulla and comprises an ellipsoidal seminal chamber that is translucent or transparent and a stalk of about the same length as the chamber.

The genital marking glands are acinous masses, sessile on the parietes, the masses circular or nearly so in outline.

Diagnosis.—Decithecal, spermathecal pores minute and superficial, 5 pairs, on 4/5-8/9. Male pores minute and superficial, each on a transversely placed marking which may be included within a genital marking. Genital markings paired, on xviii. Setal circles present on all clitellar segments; v/9-10, vi/7-11, vii/9-11, viii/9-12, xvii/8-11, xviii/4-8, xix/9-11, 31-35/iii, 42-45/viii, 43-46/xii, 42/xx. First dorsal pore on 12/13. Clitellum terminates anterior to the setae of xvi. Length 50-80 mm. Diameter 2-3 mm. Segments 78.

Septum 9/10 present and muscular. Intestinal caeca simple but with margins incised, in xxii. Last hearts in xii. Testis sacs unpaired and horseshoe-shaped; anterior seminal vesicles included. Spermathecal diverticulum shorter than combined lengths of duct and ampulla, passing into the anterior face of the duct at the parietes, comprising an ovoidal to ellipsoidal seminal chamber and a stalk that may be as long as or longer than the chamber. Genital marking glands sessile on the parietes.

Distribution.—Trivandrum, Travancore; Hyderabad, Deccan. Outside of India known from the Philippines, Java, Penang, Trinidad, Grenada and St. Thomas. The species has been recorded only twice from the *Pheretima* domain; once from Java—3 specimens from Malan, and once from the Philippines, 371 (?) specimens from some locality on Luzon or Mindonoro. The original home of the species is to be looked for either in the Philippines or in the region between those islands and Java.

Pheretima campanulata (Rosa).

1890. *Perichaeta campanulata*, Rosa, *Ann. Mus. Genova*, XXX, p. 115. (Type locality, Palon, Burma. Types in the Genoa Museum.)

1923. *Pheretima houlleti* (part), Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 304. (Excluding synonymy and distribution of forms with only one stalked gland to the spermathecal pore invagination and also forms with no copulatory chambers.)

1931. *Pheretima campanulata* var. *penetralis*, Gates, *Rec. Ind. Mus.* XXXIII, p. 435.

Material examined.—From the Indian Museum : 1 clitellate specimen labelled, " On the hillside near Pashok bungalow. S. L. Hora ".

Diagnosis.—Sexthecal, spermathecal pores minute and invaginate, each pore on a tiny conical protrusion into an invagination with transversely slit-like lumen and aperture; three pairs, on 6/7-8/9. Male pores minute and invaginate, each pore on a penial body with a trilobed tip within a spheroidal copulatory chamber, a genital marking on each of the two lateral lobes of the penial body. Genital markings tiny, circular, greyish, translucent areas, sharply demarcated by slight circumferential furrows, on the margins of segments near 6/7-8/9 or on the intersegmental furrows, median to the secondary spermathecal apertures, and in addition internally; one marking on the anterior wall and one on the posterior wall of each spermathecal invagination, a group of 3-5 markings within each copulatory chamber in addition to markings at the base and at the tip of the penial body. Setal circles present on all clitellar segments, clitellar setae with bifid tips, 1-2 penial

setae within the wall of each copulatory chamber: vii/11-15, viii/14-19, xvii/18-22, xviii/9-17, xix/17-21, 20-25/iii, 33-43/viii, 44-52/xii, 50-61/xx. First dorsal pore on 11/12. Length 107-200 mm. Diameter 4-7 mm. Segments 107-136.

Intestinal caeca simple. Testis sacs unpaired and ventral. Lumen in ental part of the spermathecal duct large and communicating with the narrowed lumen of the ectal portion of the duct through a tiny, slit-like pore on the bluntly rounded, dorsal face of a conical papilla; diverticulum comprising a short, slender stalk and an elongate seminal chamber, the latter slightly widened entally and looped, often in an approximation to zigzag. One or more stalked glands on the posterior face of each copulatory chamber, three or more on the anterior face; one stalked gland to the anterior face and one to the posterior face of each spermathecal invagination. Genital marking glands stalked and coelomic.

Distribution.—Kalimpong and Pashok, Darjiling district, Eastern Himalayas. Outside of India; Burma, China (Yunnan), Siam, Malay Peninsula (Kuala Lumpur), Andaman Islands.

Pheretima diffringens (Baird).

1869. *Megascolex diffringens*, Baird, *Proc. Zool. Soc. London*, 1869, p. 40. (Type locality, Plas Machynlleth, Montgomeryshire, North Wales. Types in the British Museum.)
1887. *Perichaeta mirabilis*, Bourne, *Proc. Zool. Soc. London*, 1886, p. 668, (Type locality, Naduvatam, Nilgiris, S. I. No types.)
1900. *Pheretima mirabilis*, Michaelsen, *Das Tierreich*, X, p. 284.
1900. *Amyntas heterochaetus* (part), Beddard, *Proc. Zool. Soc. London*, 1900, p. 622.
1909. *Pheretima heterochaeta*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 189.
1910. *Pheretima heterochaeta*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX, (5), pp. 11 and 83.
1914. *Pheretima heterochaeta*, Stephenson, *Rec. Ind. Mus.* VIII, p. 399 and X, p. 343.
1915. *Pheretima heterochaeta*, Stephenson, *Mem. Ind. Mus.* VI, p. 99.
1916. *Pheretima heterochaeta*, Prashad, *J. Bombay Nat. Hist. Soc.* XXIV, p. 503.
1916. *Pheretima heterochaeta*, Stephenson, *Rec. Ind. Mus.* XII, p. 334.
1917. *Pheretima heterochaeta*, Stephenson, *Rec. Ind. Mus.* XIII, p. 385.
1917. *Pheretima heterochaeta*, Stephenson, *Quart. J. Mic. Sci.* LXII, p. 265. (Pharyngeal gland cells.)
1918. *Pheretima heterochaeta*, Thapar, *Rec. Ind. Mus.* XV, pp. 71 and 73. (Lymph glands.)
1919. *Pheretima heterochaeta*, Bahl, *Quart. J. Mic. Sci.* LXIV, p. 104 (Nephridia), and p. 111 (Septa).
1920. *Pheretima heterochaeta*, Stephenson, *Mem. Ind. Mus.* VII, p. 222.
1921. *Pheretima heterochaeta*, Stephenson, *Rec. Ind. Mus.* XXII, p. 760.
1922. *Pheretima heterochaeta*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 433.
1923. *Pheretima heterochaeta* (part, excluding synonymy and distribution of forms with copulatory chambers), Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 302.
1924. *Pheretima heterochaeta*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 339.
1924. *Pheretima heterochaeta*, Stephenson, *Proc. Roy. Soc. London*, B. XCVII, pp. 179, 188, 198, and 201. (Blood glands.)
1925. *Pheretima heterochaeta*, Stephenson, *Rec. Ind. Mus.* XXVII, p. 59.
1925. *Pheretima heterochaeta*, Stephenson, *Proc. Zool. Soc. London*, 1925, p. 893.
1931. *Pheretima heterochaeta*, Gates, *Rec. Ind. Mus.* XXXIII, pp. 387 and 437.
1934. *Pheretima mirabilis*, Gates, *Rec. Ind. Mus.* XXXVI, p. 260,

Material examined.—From the Indian Museum.—92 clitellate specimens labelled, " Dumpep, Khasi Hills, Assam. Dr. S. L. Hora ", 49 clitellate specimens labelled, " Teesta Bridge[1] Teesta Valley. Dr. S. L. Hora ", 1 aclitellate and 7 clitellate specimens labelled, " Kalimpong, E. Himalayas. Dr. S. L. Hora ", 1 clitellate, macerated specimen labelled, Dharamshala Cantonment, Kangra Dt., Punjab. Dr. S. L. Hora ", 9 clitellate specimens labelled, " Dhobijhora, Kurseong, Darjeeling. Md. Sharif ", 2 clitellate specimens labelled, " Kotla, Kangra Dt., Punjab. Dr. S. L. Hora ", 13 aclitellate, macerated specimens labelled, " Kangra, Punjab. Dr. S. L. Hora ", 4 clitellate specimens labelled, " Palampur, Kangra Dt., Punjab. Dr. S. L. Hora ", 1 clitellate specimen labelled, " Kodaikanal, Palni Hills, S. India. Dr. S. L. Hora ", 41 clitellate specimens labelled, " Benhope, Nilgiris. Dr. S. L. Hora ", 5 clitellate specimens labelled, " Fern Hill, Nilgiris. Dr. S. L. Hora ". From the Madras Museum.—27 clitellate specimens labelled, " From a pit containing decomposing cow dung and vegetable matter, Coonoor, Nilgiris. Major K. R. K. Iyenger, I. M. S.", 1 aclitellate and 21 clitellate specimens labelled, " From garden soil, Coonoor, Nilgiris. Major K. R. K. Iyenger, I. M. S.". From the Fisheries Reserve Officer.—3 clitellate specimens labelled, " Fern Hill. 6-8. x ·35.". From Prof. K. N. Sharma.—13 aclitellate and 55 clitellate specimens labelled, " Near Katmandu, Nepal."

External characteristics.—The setal numbers of five Nepal specimens are shown below :—

iii	vi	viii	xii	xx
26	33	40	43	51
25	32	37	45	49
24	32	35	41	43
27	28	36	42	49
28	32	35	41	50

The clitellum, on nearly all of the mature Nepal specimens, extends slightly anterior to 13/14 and slightly posterior to 16/17, intersegmental furrows 13/14 and 16/17 not visible but the sites of the occluded dorsal pores of those two furrows visible.

The first dorsal pore is on 11/12 (all Nepal specimens) except that two worms have a definitely pore-like marking on 10/11.

On the Nepal worms there are no postsetal or postclitellar genital markings. The presetal genital markings are paired, on some or all of vii-ix. Each marking is approximately in *cd*.

Of the Madras specimens, 19 have paired presetal genital markings on vii-ix, while 14 have similar markings on vii-viii only. Other worms lack some or all of these markings. The markings are usually slightly nearer to the setae than to the intersegmental furrow and are either in *c*, *cd*, or *d*. A number of the Madras specimens have paired, postsetal genital markings on vi-viii, immediately in front of the spermathecal pores.

Nearly all of the Dumpep specimens have three pairs of postsetal genital markings, one marking immediately in front of each spermathecal pore on 6/7-8/9. One specimen has in addition postsetal markings on v. Nearly all of these worms have two pairs of presetal markings on vii-viii while one specimen also has presetal markings on ix.

[1] Teesta Bridge, according to Dr. S. L. Hora, is about 33 miles from Siliguri Ry. station and at an elevation of 500-700 feet.

Internal anatomy.—There is a pair of hearts belonging to ix in 5 specimens, a single heart belonging to ix, on the right side in 16 specimens, on the left side in 19 specimens. There are no hearts belonging to x in 26 specimens; a single heart belonging to x, on the left side in 6 specimens, on the right side in 7 specimens. One worm has a pair of hearts belonging to x (Nepal specimens).

The seminal chamber of the spermathecal diverticulum is about twice as long as thick, the chamber about three times as thick as the stalk and one-half to one-third as long as the stalk.

Abnormality.—Two of the Teesta Valley specimens are abnormal. One worm varies from normal as follows:—The right male pore is on xx, on the left side an additional male pore on xvii. The clitellum extends on the right side to 17/18. The other worm varies from normal as follows.—Spermathecal pores on 7/8-12/13. Female pores on xvii, xviii and xix. Male pores on the left side on xxiii and xxiv, on the right side on xxiv. The clitellum extends from a posterior portion of xvii on to xxii. Presetal genital markings on the left side of viii and the right side of ix; postsetal markings on the right side of viii and the right and left sides of ix. (There are no spiral, metameric abnormalities.) The gizzard is in xi-xiii, septa 10/11-12/13 lacking.. The intestine begins in xvi, the right intestinal caecum extending through xl-xxxviii, the left through xxxix-xxxvii. Testis sacs in xiii and xiv. Seminal vesicles in xiv and xv. No prostates. Paired ovaries and oviducal funnels in xvi, xvii and xviii. The single heart of xii on the right side, of xiii on the left side, the last hearts in xvi.

Diagnosis.—Octothecal, spermathecal pores minute and superficial, four pairs, on 5/6-8/9. Male pores minute and superficial, each pore at the centre of a transvesely placed, disc-shaped porophore. Genital markings small, circular to shortly elliptical tubercles, paired; presetal on vi-ix, in *cd* or (and) about in *bc*, postsetal on v-viii and just in front of the spermathecal pores. Setae: vi/6-11, vii/8-14, viii/10-16, xvii/13-18, xviii/9-16, xix/12-17, 21-28/iii, 26-36/vi, 35-42/viii, 39-45/xii, 42-52/xx. First dorsal pore on 11/12. Length 45-170 mm. Diameter 3-6 mm. Segments 90-113.

Intestinal caeca simple. Hearts of x lacking. Testis sacs unpaired and ventral. Spermathecal diverticulum with long stalk and shorter, thicker, ovoidal, simple seminal chamber. Genital marking glands stalked and coelomic.

Distribution.—Peshawar, Mardan, Northwestern Frontier; Lahore, Dharamsala Cantonment, Kotla, Kangra, Palampur, Punjab; Simla, Naini Tal, Western Himalayas; Nepal, Darjiling, Kurseong, Kalimpong, Teesta Bridge, Singla, Ghum, Sureil, Pashok, Darjiling district, Gangtok (Sikkim), Kobo (Abor country), Eastern Himalayas; Cherrapunji, Sadiya, Myntaung Valley, Shillong, Imphal (Manipur), Dumpep, Assam; Siliguri, Rangamati (Chittagong Hill Tracts), Bengal; Kodaikanal, Tiger Shola (Palni Hills), Naduvatam, Benhope, Kotagiri, Fern Hill, Coonoor (Nilgiri Hills), Bababudan Hills (Mysore), South India.

Outside of India: Ceylon, Burma (Shan Plateau and Bhamo district only), China (Provinces of Yunnan, Szechuan, Chekiang, Kiangsi, Kiangsu, Anhwei, Fukien, as well as Hongkong), Java, Sumatra, New

Caledonia, Australia, Hawaiian Islands, Transvaal, Natal, Madagascar, Anjouan, Cape Verde, St. Helena, Sardinia, Azores, Poland,* Scotland,* Wales,* Italy, Portugal, France, United States, Mexico, Costa Rica, San Domingo, Colombia, Peru.

Pheretima elongata (Perrier).

1872. *Perichaeta elongata*, E. Perrier, *N. Arch. Mus. Paris*, VIII, p. 124. (Type locality, Peru ! Type in the Paris Museum.)
1909. *Pheretima biserialis*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 187.
1910. *Pheretima elongata*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), pp. 11 and 84.
1920. *Pheretima elongata*, Stephenson, *Mem. Ind. Mus.* VII, p. 222.
1922. *Pheretima elongata*, Michaelsen, *Mitt. Mus. Hamburg*, XXXVIII, p. 68.
1922. *Pheretima elongata*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 433.
1923. *Pheretima elongata*, Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 298.
1924. *Pheretima elongata*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 433.
1926. *Pheretima elongata*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 256.

Diagnosis.—Multithecal, spermathecal pores minute and superficial, in paired groups of 2-4, on or near to 5/6-6/7. Male pores minute and invaginate, each pore on a disc-shaped porophore on the median wall of a parietal invagination with a crescentic aperture. Genital markings transversely elliptical, presetal, widely paired, on xix-xxiv. Setae: xvii/12-17, xviii/10-15, xix/12-15, 50-66/iii, 67-104/viii, 54-80/xii, 55-75/xx. First dorsal pore on 12/13. Length 85-300 mm. Diameter 3½-6 mm. Segments 169-241.

Testis sacs unpaired and annular; seminal vesicles as well as hearts of x and xi included. Spermathecal diverticulum with stalk longer than the ovoidal to ellipsoidal seminal chamber. Genital marking glands sessile on the parietes.

Remarks.—*P. elongata* is usually athecal. Absence of spermathecae, as in *P. anomala*, is regarded as an abnormality. Thecal specimens do not have a symmetrically paired arrangement of the spermathecae, the latter either asymmetrical or in groups. A grouped arrangement of the spermathecae characterizes a subgenus of *Pheretima* recently erected by Michaelsen (1934, p. 15). The subgenus *Polypheretima* is further distinguished only by the absence of intestinal caeca. *P. elongata* which is acaecal and when thecal often with a multithecal arrangement of the spermathecae, may possibly have originated in Michaelsen's *Polypheretima* region, an area including the southern portion of the Malay Peninsula, Borneo, Celebes and New Guinea. Actually *P. elongata* is close to *P. stelleri* (Michaelsen), 1891. This species cannot at present be adequately characterized and is possibly a conglomerate of two or more species.

Distribution.—Poona, Bombay, Manmad and Karachi in Bombay Presidency; Palia, Indore and Ujjain in Central India; Namkhana (Sunderbans) and Calcutta in Bengal; Hyderabad, Deccan; Mockoli, Bhaganamola, Manakoti (Curg), Shimoga (Mysore), Singanallur (Coimbatur district) in South India. Outside of India: Ceylon, Burma, Andaman Islands, Siam, Sumatra, Java, Celebes, Philippines, New Caledonia, Sumba, Salibaboe, Kei, Flores and Hawaiian Islands, Madagascar, Porto Rico, Hayti, Cuba, Panama, Peru, Venezuela, British and Dutch Guiana.

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* **Only in greenhouses.**

Pheretima hawayana (Rosa).

1891. *Perichaeta hawayana*, Rosa, *Ann. Hofmus. Wien*, VI, p. 396. (Type locality, Hawaii. Type in the Vienna Museum.)
1909. *Pheretima hawayana f. typica*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 187.
1910. *Pheretima hawayana f. typica*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), pp. 11 and 83.
1914. *Pheretima hawayana* (part), Stephenson, *Rec. Ind. Mus.* X, p. 343. (Excluding quadrithecal forms.) Although none of these specimens have been preserved in the Indian Museum, individuals with enlarged setae on iv-viii or v-vii must be referred to *hawayana*.
1916. *Pheretima hawayana typica* (part) + *P. h. barbadensis* (part), Prashad, *J. Bombay Nat. Hist. Soc.* XXIV, pp. 499 and 501. (Excluding quadrithecal forms.)
1916. *Pheretima hawayana f. typica*, Stephenson, *Rec. Ind. Mus.* XII, p. 334.
1923. *Pheretima hawayana* (part), Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 300. (Excluding synonymy and distribution of quadrithecal forms.)
1925. *Pheretima hawayana*, Stephenson, *Rec. Ind. Mus.* XXVII, p. 59.
1934. *Pheretima hawayana*, Gates, *Rec. Ind. Mus.* XXXVI, p. 259.

Material examined.—From the Indian Museum: 5 clitellate specimens labelled, "*Pheretima hawayana* (Rosa). Under stones in thicket of trees, Kurseong, E. Himalayas. Sta. 13. 5,000 feet. 9. iii. 24. Dr. B. N. Chopra. W 1221/1.", 1 clitellate anterior fragment and 1 aclitellate specimen labelled, "*Pheretima hawayana forma typica*. Kurseong, E. Himalayas. 4,500 feet. 26. iii. 10. Dr. F. H. Gravely. ZEV 6540/7.", 1 clitellate specimen labelled, "*Pheretima hawayana forma typica*. Kurseong, E. Himalayas. E. Bergtheil, Esq. ZEV 2826/7.", 3 clitellate specimens labelled, "*Pheretima hawayana forma typica*. Kurseong, E. Himalayas. 5,000 feet, 13-16. vii. 07. Mus. Coll. (R. Hodgart). ZEV 4154/7.", 1 clitellate specimen labelled, "*Pheretima hawayana forma typica*. Ramnee, Garwhal Dist. U. P. 20-10-07. Mus. Coll. (R. Hodgart). ZEV 4188/7.", 3 clitellate specimens labelled, "*Pheretima hawayana forma typica*. Tengyueh, Yunnan. J. Coggin Brown. ZEV 4892/7.", and 1 clitellate specimen labelled, "*Pheretima hawayana forma typica*. Pattipola (Hill Country) Ceylon. Dr. N. Annandale. ZEV 5085/7.". The Yunnan tube contains, in addition to the *P. hawayana*, 1 macerated and 1 well preserved specimen of *P. californica* Kinberg 1867.

One of Dr. Chopra's specimens from Kurseong has twelve postsetal genital markings on xviii, in two groups of six each. One of Hodgart's specimens from Kurseong has eight postsetal genital markings on xviii.

Diagnosis.—Sexthecal, spermathecal pores minute and superficial, three pairs, on 5/6-7/8. Male pores minute and superficial, each pore at the centre of a small, transversely elliptical, disc-shaped porophore. Genital markings small, paired tubercles; postsetal on vii-viii and slightly median to the spermathecal pore lines; on xviii, in or just behind the setal circle and just median to the male pore lines. Setae present ventrally on xvi: vi/4-8, vii/10-15, xvii/15-20, xviii/10-15, xix/16-20, 17-21/iii, 36-40/viii, 44-49/xii, 48-56/xx. First dorsal pore on 10/11. Length 60-112. Diameter 3-4 mm. Segments 71-91.

Intestinal caeca simple, with a few short lobes on the ventral margin. Testis sacs unpaired and ventral. Spermathecal diverticulum with stalk longer than the seminal chamber and with irregular lumen, seminal chamber slenderly club-shaped. Genital marking glands stalked and coelomic.

Distribution.—Kurseong in the Eastern Himalayas, Shillong in Assam, Ramnee in the United Provinces, Lahore in the Punjab. Stephenson (1923, p. 302) includes Rangamati in the distribution of the species but no record of this can be found. Outside of India: Ceylon

(Pattipola), Burma (Namkham, Kawngmu, Kutkai, Lashio and Mogok, all on the Shan Plateau), China (Provinces of Chekiang, Szechuan, Yunnan, Fukien, also Hongkong), Borneo, Samoa, Hawaiian and Fiji Islands, Bermuda, Barbados, United States (southern), Brazil, Uruguay and Chile.

Pheretima houlleti (Perrier).

1872. *Perichaeta houlleti*, E. Perrier, *N. Arch. Mus. Paris*, VIII, p. 99. (Type locality, Calcutta. Types in the Paris Museum.)
1889. *Megascolex Houlleti*, Vaillant, *Hist. Nat. Annel.* III, (1), p. 75.
1895. *Perichaeta houlleti* (part), Beddard, *Monog.*, p. 424. (Excluding *P. campanulata.*)
1898. *Perichaeta crescentica*, Fedarb, *Proc. Zool. Soc. London*, 1898, p. 447. (Type locality, Dehra Dun. Types probably in the British Museum. *Vide* note below.)
1898. *Perichaeta travancorensis*, Fedarb, *J. Bombay Nat. Hist. Soc.* XI, p. 435. (Type locality, Travancore. Types in the British Museum. The types were obtained by the Museum on the purchase of Beddard's collection. It is probable that specimens labelled *crescentica* and obtained in the same way and from the type locality of this species are actually the types.)
1900. *Pheretima crescentica* + *P. houlleti* (part, excluding at least *campanulata*, *guillelmi* and possibly also *udekemi*) + *P. travancorensis*, Michaelsen, *Das Tierreich*, X, pp. 262, 273 and 310.
1900. *Amyntas houlleti* (part, excluding at least *campanulata* and *guillelmi*) + *A. travancorensis*, Beddard, *Proc. Zool. Soc. London*, 1900, pp. 613 and 614.
1903. *Pheretima Houlleti* (part, excluding distribution of *campanulata* and Bahama forms) + *P. travancorensis*, Michaelsen, *Geogr. Verbr.* pp. 97 and 100.
1909. *Pheretima houlleti* (part, excluding the distribution of *campanulata*) + *P. travancorensis* + *P. houlleti*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 187.
1910. *Pheretima houlleti* (part, excluding the distribution of *campanulata*, *guillelmi* and *meridiana*) + *P. travancorensis* + *P. houlleti*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), pp. 11, 13 and 83.
1911. *Pheretima travancorensis*, Cognetti, *Ann. Mag. Nat. Hist.* (8), VII, p. 494.
1916. *Pheretima houlleti*, Stephenson, *Rec. Ind. Mus.* XII, p. 334.
1916. *Pheretima trivandrana*, Stephenson, *Rec. Ind. Mus.* XII, p. 335. (Type locality, Trivandrum, Travancore. Type in the Indian Museum).
1917. *Pheretima houlleti*, Stephenson, *Rec. Ind. Mus.* XIII, p. 385.
1922. *Pheretima houlleti*, Michaelsen, *Mitt. Mus. Hamburg*, XXXVIII, p. 68.
1922. *Pheretima houlleti*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 434.
1923. *Pheretima houlleti* (part, excluding *campanulata* and the distribution of *guillelmi* and *meridiana*) + *P. travancorensis* + *P. trivandrana*, Stephenson, *Oligochaeta*, in *F. B. I. Series*, pp. 304, 313 and 314.
1924. *Pheretima houlleti*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 340.
1929. *Pheretima travancorensis* + *P. trivandrana*, Aiyer, *Rec. Ind. Mus.* XXXI, p. 15.
1934. *Pheretima houlleti*, Gates, *Rec. Ind. Mus.* XXXVI, p. 259.

Material examined.—From the Indian Museum : 12 clitellate specimens labelled, "*Pheretima houlleti* (E. Perr.) Bhim Tal, Kumaon ; 4,500 ft. alt., N. A., 19-28. ix. 06. ZEV 2825/7.", 4 clitellate specimens of which two are dissected, labelled, "*Pheretima houlleti* (E. Perr.). Raniganj, Burdwan dist., Bengal. L. L. Fermor. ZEV 2824/7.", 1 dissected, clitellate specimen labelled, "*Pheretima houlleti* (E. Perr.). Mangalore, Malabar. G. Matthai. ZEV 4143/7.", 2 dissected, clitellate specimens labelled, "*Pheretima houlleti* (E. Perr.). Trichur (Cochin State) Malabar, Madras Pres. July 1909. G. Matthai. ZEV 3504/7.", 1 aclitellate, dissected specimen labelled, "*Pheretima houlleti* (E. Perrier). Trivandrum, Travancore. Trivandrum Museum. "Type". ZEV 7233/7.", 1 clitellate, dissected specimen labelled, "*Pheretima houlleti.* Rawal Pindi, Punjab. Dec. 1915. Ragunath Sahai. Lt. Col. J. Stephenson, I.M.S. W 41/1.", 1 dissected, clitellate specimen labelled, "*Pheretima houlleti* (E. Perr.) Bombay. J. P. Mullan. W 1165/1.", 1 clitellate, macerated, dissected

specimen labelled, "*Pheretima houlleti* (E. Perr.). Compound of the Forest Research Institute, Dehra Dun. 20. viii. 21. W 686/1.", 2 clitellate, dissected specimens labelled, "*Pheretima houlleti* (E. Perr.). Khasi Hills, Sta. 5, Under stones and in muddy pools around Dak bungalow at Cherrapunji, Assam. 28. x. 1921. S. L. Hora. W 685/1.", 1 clitellate, dissected specimen labelled, "*Pheretima houlleti* (E. Perr.). Matheran. x. 21. J. P. Mullan. W 1164/1.", and 2 clitellate, dissected specimens labelled, "*Pheretima houlleti* (E. Perr.). Gorge below Chota tank, Buldana, Berar. 2190 ft. Sta. 7, 17, ii. 23. H. S. Rao. W 1128/1.". From the British Museum : 1 aclitellate and 3 clitellate dissected specimens labelled, "*Pheretima travancorensis* (type) 1904. 10. 5. 167/8. coll. Beddard.".

Remarks.—The types of *P. travancorensis* are quite obviously referable to *houlleti.*

With the exceptions noted below, all of the Indian Museum material can be referred, without question, to *houlleti.* One lot of specimens from Bombay (Stephenson) and others from Malabar (Chevagun bei Calicut), Trivandrum, Coorg and Mysore (Michaelsen) have not been available for examination. There is, however, no evidence to indicate that any of these specimens might be anything but *houlleti.*

The Mangalore specimen is peculiar in that some of the spermathecal pore invaginations have the posterior stalked gland characteristic of *campanulata* and *meridiana.* The left spermathecal invagination of vii has two anterior stalked glands. The penial body is slenderly conical, genital markings apparently lacking thereon or nearby, the shape much more like that of *houlleti* than that of either *campanulata* or *meridiana.* The first dorsal pore is definitely on 8/9. The size is well within the *houlleti* limits. In spite of the presence of the posterior stalked glands the other characteristics just mentioned necessitate identification as *houlleti.* The presence of posterior stalked glands on the spermathecal invagination is accordingly regarded as an abnormality, associated with an abnormal doubling of the anterior glands. The doubling of the anterior glands has been observed previously but the presence of posterior glands on the spermathecal pore invagination has not hitherto been noted in *P. houlleti.*

One specimen labelled, "*Pheretima houlleti* (E. Perr.) Bansda, Surat. October 1922. J. P. Mullan. W 1166/1.", is macerated and lacks at least a portion of the anterior end. Identification in the present condition is not feasible, but paired, rather thread-like segmental structures are almost certainly meganephridia. It is highly improbable that Stephenson mistook a meganephric worm for *P. houlleti,* which is purely micronephric. Presumably labels or specimens have been accidentally changed. Hence the Surat record has not been questioned.

Diagnosis.—Sexthecal, spermathecal pores minute and invaginate, each pore on the roof or lateral wall near the roof of an invagination with transversely slit-like lumen and aperture ; three pairs, on 6/7-8/9. Male pores minute and invaginate, each pore on a slenderly conical to shortly columnar penis on the roof of a spheroidal copulatory chamber. Genital markings tiny, circular, greyish translucent areas sharply demarcated by slight circumferential furrows, internal only ; one marking on the anterior wall of each spermathecal pore invagination, one marking on the median wall of each copulatory chamber, one to three markings on or near the base of each penis. Seta *a* and some of the ventral setae of the preclitellar segments enlarged, modified and ornamented ;

setae present on all clitellar segments and with bifid or trifid tips: vii/11-17, viii/16-25, xvii/12-16, xviii/5-12, xix/12-15, 24-31/iii, 37-51/viii, 46-54/xii, 51-61/xx. First dorsal pore on 7/8-10/11. Length 55-110 mm. Diameter 3-4½ mm. Segments 90-116.

Intestinal caeca simple. Testis sacs unpaired and ventral. Lumen in ental part of the spermathecal duct wide and communicating with the narrowed lumen of the ectal portion of the duct through a tiny, slit-like aperture at the centre of a low, disc-shaped papilla of circular outline; diverticulum with short, straight stalk and wider, elongate seminal chamber, the latter looped in part or in whole, often in an approximation to zigzag. One or more stalked glands to the anterior face of each copulatory chamber, one stalked gland on the posterior face; one stalked gland to the anterior face of each spermathecal invagination.

Distribution.—Rawalpindi, Punjab; Dehra Dun, Bhim Tal, Allahabad, United Provinces; Calcutta, Raniganj (Burdwan district), Bengal; Cherrapunji, Assam; Bombay, Matheran, Bansda (Surat), Bombay Presidency; Buldana (Berar), Central Provinces; Mangalore, Trivandrum (Travancore), Trichur (Cochin), Chevagun (near Calicut), Merkara (Coorg), Shimoga, Bangalore (Mysore), Salem, South India. Outside of India: Ceylon (Panadhure), Burma (widely spread), Andaman Islands, Siam, Malay Peninsula. *P. houlleti* has been recorded from other places but in view of the confusion of at least three species with *houlleti* the records require confirmation. There is no valid record of the occurrence of the species in China, outside of the province of Yunnan.

Pheretima morrisi (Beddard).

1892. *Perichaeta morrisi*, Beddard, *Proc. Zool. Soc. London*, 1892, p. 166. (Type locality, Penang. Types in the British Museum.) According to Beddard the types are from Penang, but the label in the tube of types states that the worms are from Hongkong.)

1898. *Perichaeta cupulifera*, Fedarb, *Proc. Zool. Soc. London*, 1898, p. 445. (Type locality, Dehra Dun. Types, if still in existence, in the British Museum.)

1900. *Pheretima barbadensis* (part, excluding sexthecal forms) + *P. morrisi*, Michaelsen, *Das Tierreich*, X, pp. 254 and 287.

1900. *Amyntas hawayanus* (part), Beddard, *Proc. Zool. Soc. London*, 1900, p. 645. (Excluding sexthecal forms.)

1903. *Pheretima hawayana* (part), Michaelsen, *Geogr. Verbr.*, p. 96. (Excluding sexthecal forms.)

1909. *Pheretima hawayana barbadensis*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 187.

1910. *Pheretima hawayana barbadensis*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), p. 11.

1914. *Pheretima hawayana* (part), Stephenson, *Rec. Ind. Mus.* X, p. 343. (Excluding sexthecal forms with enlarged setae on iv-viii or v-vii.)

1916. *Pheretima hawayana typica* (part) + *P. h. barbadensis* (part), Prashad, *J. Bombay Nat. Hist. Soc.* XXIV, pp. 499 and 501. (Excluding sexthecal forms.)

1917. *Pheretima hawayana*, Stephenson, *Rec. Ind. Mus.* XIII, p. 386.

1920. *Pheretima hawayana*, Stephenson, *Mem. Ind. Mus.* VII, p. 222. (All of Stephenson's specimens of *hawayana* from Bombay that have been preserved in the Indian Museum are referable to *morrisi*.)

1921. *Pheretima hawayana*, Stephenson, *Rec. Ind. Mus.* XXII, p. 760.

1922. *Pheretima hawayana*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 433.

1923. *Pheretima hawayana* (part), Stepehnson, *Oligochaeta*, in *F. B. I. Series*, p. 300. (Excluding sexthecal forms.)

1924. *Pheretima hawayana*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 339. (*Vide* note under Stephenson, 1920.)

1926. *Pheretima hawayana*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 256. (*Vide* note under Stephenson, 1920.)

Material examined.—From the Indian Museum: 10 clitellate or partially clitellate specimens labelled, "*Pheretima hawayana* (Rosa). Lahore, Punjab. Lt.-Col. J. Stephenson. W 49/1.", 1 aclitellate specimen labelled, "*Pheretima hawayana* (Rosa). Nepal Valley, E. Himalayas. 4,500-6,500 feet. Lt.-Col. J. Manners-Smith. W 74/1.", 7 clitellate specimens labelled, "*Pheretima hawayana* (Rosa). Brindaban, Muttra Dist. U. P. 15. vii. 17. Dr. B. Prashad. W 233/1.", 5 clitellate specimens labelled, "*Pheretima hawayana* (Rosa). Udaipur, Rajputana. March 1918. Lt.-Col. J. Stephenson. W 234/1.", 4 clitellate macerated specimens labelled, "*Pheretima hawayana* (Rosa). Compound of Forest Res. Inst. Dehra Dun. 20. viii. 21. W 682/1.", 4 clitellate specimens labelled, *Pheretima hawayana* (Rosa). Imphal Residency Garden, Manipur. 2. iii. 20. Manipur Survey. W 566/1.", 1 aclitellate and 1 clitellate specimens labelled, "*Pheretima hawayana* (Rosa). Bombay. Prof. J. P. Mullan. W 1163/1.", 13 clitellate, macerated specimens labelled, "*Pheretima hawayana* subsp. *barbadensis*. Lahore, Punjab. Major J. Stephenson. ZEV 2827/7.", and 1 aclitellate and 6 clitellate specimens labelled, "Kalimpong, E. Himalayas. June 1934. S. L. Hora.".

One of Stephenson's specimens from Lahore has a transverse, presetal row of 8 markings on xviii, a transverse row of 7 presetal markings on xix, in addition to the usual pair of markings just median to each male porophore. Other specimens from Lahore have several presetal genital markings on each of segments xviii and xix in addition to the markings close to the male porophores. Four of the Kalimpong specimens have a presetal row of markings on xvii, of 5 markings (3 specimens) or of 6 markings (1 specimen). One of these specimens has in addition 5 presetal markings on xix. One of Mullan's specimens from Bombay has an extra male pore on xvii on the left side and just median thereto a pair of markings, one presetal and one postsetal. Associated with the extra male porophore is a well-developed prostate and prostatic duct. On one of the Manipur Survey specimens the median presetal marking on vii is replaced by a pair of markings in contact at the midventral line.

Diagnosis.—Quadrithecal, spermathecal pores minute and superficial, two pairs, on 5/6-6/7. Male pores minute and superficial, each pore on a tiny, transversely elliptical, disc-shaped porophore. Genital markings small, transversely elliptical to circular tubercles; two just median to each male porophore with one presetal and one postsetal; presetal and median on v-viii; presetal and just median to the spermathecal pore lines on vii-viii; presetal and median to the male pore lines on xviii-xix, postsetal and median to the male pore lines on xvii-xviii. Setae present ventrally on xvi: vi/16-28, xvii/16-23, xviii/10-17, xix/16-23, 23-29/iii, 46-51/viii, 48-56/xii, 4-22/xvi, 46-59/xx. First dorsal pore on 10/11. Length 40-150 mm. Diameter $2\frac{1}{2}$-6 mm. Segments 87-95.

Intestinal caeca simple, with a few short lobes on the ventral margins. Testis sacs paired and ventral. Spermathecal diverticulum with short stalk-lumen narrow and irregular, a middle portion with high and thick transverse ridges, seminal chamber slenderly club-shaped. Genital marking glands stalked and coelomic.

Distribution.—Lahore, Punjab; Dehra Dun, Bindraban near Muttra, United Provinces; Nepal Valley, and Kalimpong, Eastern Himalayas; Imphal, Manipur; Udaipur, Rajputana; Bombay. Outside of India: Burma (widely distributed on the Shan Plateau and also known from

Myitkyina and Bhamo district and from Mt. Popa in Myingyan district), China (provinces of Yunnan, Szechuan, Fukien and Chekiang, also Hongkong), Siam (Chiengmai), Penang, Sumatra, Hawaiian Islands, Cape Verde, St. Helena, Barbados, United States (southern), Brazil and Chile.

Pheretima planata Gates.

1926. *Pheretima planata*, Gates, *Ann. Mag. Nat. Hist.* (9), XVII, p. 411. (Type locality, Rangoon.)
1926. *Pheretima planata*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 256.

Diagnosis.—Quadrithecal, spermathecal pores minute and superficial, two pairs, on the anterior margins of vii and viii close to 6/7 and 7/8. Male pores minute and invaginate, each pore on the roof of a copulatory chamber with a transversely slit-like aperture. Genital markings tiny, circular, translucent areas; external markings on the posterior margins of vii and viii and the anterior margin of viii, 1-4 markings just median to each spermathecal pore; internal markings 8-12, on the roof and walls of the copulatory chamber. Setae; vii/35-42, xvii/17-22, xviii/9-14, xix/16-20, 60-67/iii, 75-87/viii, 63-78/xii, 56-65/xx. First dorsal pore on 11/12. Length 64-170 mm. Diameter 4-7 mm. Segments 115-142.

Intestinal caeca simple. Testis sacs paired; of x, ventral; of xi, vertical; seminal vesicles included. Spermathecal diverticulum longer than combined lengths of duct and ampulla, comprising a short stalk, a thicker middle portion with thick wall within which are numerous small, spheroidal to ovoidal chambers opening into the central lumen, and a terminal, elongately ellipsoidal seminal chamber. Genital marking glands stalked and coelomic.

Distribution.—Katlicherra in South Cachar, Assam. Outside of India found in Burma, Andaman Islands and the Malay Peninsula (Kuala Lumpur).

Pheretima posthuma (Vaillant).

1868. *Perichaeta posthuma*, L. Vaillant, *Ann. Sci. Nat.* (5), X, p. 228. (Type locality, Java' Types in the Paris Museum.)
1883. *Megascolex affinis*, Beddard, *Ann. Mag. Nat. Hist.* (5), XII, p. 214.
1889. *Megascolex posthuma*, Vaillant, *Hist. Nat. Annel.* III, (1) p. 72.
1895. *Perichaeta posthuma*, Beddard, *Monog.* p. 424.
1900. *Pheretima posthuma*, Michaelsen, *Das Tierreich*, X, p. 295.
1900. *Amyntas posthumus*, Beddard, *Proc. Zool. Soc. London*, 1900, p. 641.
1901. *Amyntas posthumus*, Beddard, *Proc. Zool. Soc. London*, 1901, p. 196.
1902. *Pheretima posthuma*, Beddard and Fedarb, *Proc. Zool. Soc. London*, 1902, p. 164. (Coelomic pouches.)
1903. *Pheretima posthuma*, Michaelsen, *Geogr. Verbr.* p. 98.
1909. *Pheretima posthuma*, Michaelsen, *Mem. Ind. Mus.* I, pp. 110 and 189.
1910. *Pheretima posthuma*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX (5), p. 12.
1911. *Pheretima posthuma*, Lloyd, *Introduction to Biology for Students in India*, p. 68.
1911. *Pheretima posthuma*, Lloyd and Powell, *J. Bombay Nat. Hist. Soc.* XXI, pp. 289 and 291.
1913. *Pheretima posthuma*, Stephenson, *Trans. Roy. Soc. Edinburgh*, XLIX, p. 764. (Circulatory System.)
1914. *Pheretima posthuma*, Stephenson, *Rec. Ind. Mus.* X, pp. 323 and 342.
1915. *Pheretima posthuma*, Stephenson, *Mem. Ind. Mus.* VI, pp. 37 and 99.
1916. *Pheretima posthuma*, Prashad, *J. Bombay Nat. Hist. Soc.* XXIV, p. 502.

1916. *Pheretima posthuma*, Prashad, "*The Anatomy of an Indian Earthworm, Pheretima posthuma.*", Lahore, p. 1.
1916. *Pheretima posthuma*, Stephenson, *Rec. Ind. Mus.* XII, p. 334.
1917. *Pheretima posthuma*, Stephenson, *Quart. J. Mic. Sci.* LXII, p. 261. (Pharyngeal gland cells.)
1917. *Pheretima posthuma*, Stephenson, *Rec. Ind. Mus.* XIII, p. 385.
1918. *Pheretima posthuma*, Thapar, *Rec. Ind. Mus.* XV, pp. 71 and 74. (Lymph glands and coelomic organs.)
1919. *Pheretima posthuma*, Bahl, *Quart. J. Mic. Sci.* LXIV, pp. 76 and 109. (Nephridia and septa.)
1920. *Pheretima posthuma*, Stephenson, *Mem. Ind. Mus.*, VII, p. 222.
1921. *Pheretima posthuma*, Bahl, *Quart. J. Mic. Sci.* LXV, pp. 349 and 354. (Circulatory system.)
1922. *Pheretima posthuma*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 434.
1922. *Pheretima posthuma*, Bahl, *Quart. J. Mic. Sci.* LXVI, p. 56. (Cocoons.)
1923. *Pheretima posthuma*, Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 309.
1924. *Pheretima posthuma*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 340.
1924. *Pheretima posthuma*, Stephenson, *Proc. Roy. Soc. London*, B, XCVII, p. 180. (Blood glands.)
1926. *Pheretima posthuma*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 258.
1926. *Pheretima posthuma*, Bahl, *Indian Zool. Mem.* I, p. 1.
1930. *Pheretima posthuma*, Nath, *Quart. J. Mic. Sci.* LXXV, p. 477. (Golgi Apparatus.)
1933. *Pheretima posthuma*, Nath, *Quart. J. Mic. Sci.* LXXVI, p. 138. (Golgi bodies.)
1934. *Pheretima posthuma*, Bahl, *Quart. J. Mic. Sci.* LXXVI, p. 567. (Castings.)
1936. *Pheretima posthuma*, Bahl, *Indian Zool. Mem.* I, 2nd ed., p. 1.

Material examined.—From the Indian Museum: 3 aclitellate (and probably also 2 juvenile) specimens labelled "On ground near the cistern of extension Filter Bed No. 7. Pulta Waterworks. Pulta Waterworks Survey.", 4 partially clitellate or aclitellate specimens labelled, "On the banks of New Filter Bed No. 3, Pulta Waterworks. Pulta Waterworks Survey.", 1 clitellate and macerated specimen labelled, "On sand in New Filter Bed No. 3. Pulta Waterworks. Pulta Waterworks Survey.", 1 juvenile and 45 clitellate specimens labelled, "Forest Rest House. Lachhiwala, Dehra Dun District. 29. ix-3. x. 35. Dr. S. L. Hora.".

Diagnosis.—Octothecal, spermathecal pores minute and superficial, four pairs, on the posterior margins of v-viii, each pore at the centre of a transversely elliptical, greyish, translucent area. Male pores minute and invaginate, each pore on a tiny tubercle on the median wall near the roof of a slight parietal invagination with a longitudinally directed, crescentic aperture. Genital markings small, transversely elliptical tubercles, two pairs, in the setal circles of xvii and xix. Setae present ventrally on the clitellar segments: vi/37-43, vii/38-44, viii/36-43, xvii/15-20, xviii/17-21, xix/16-20, 90-104/iii, 106-129/viii, 63-75/xii, 64-86/xx. First dorsal pore on 12/13. Length 60-140 mm. Diameter 4-8 mm.

Septum 8/9 present and muscular. Intestinal caeca simple, small. Hearts of x and xi replaced by commissural loops connecting the supra-oesophageal and suboesophageal vessels. Testis sacs unpaired: of x ventral, of xi U-shaped; seminal vesicles included. Lumen in ental part of the spermathecal duct large and communicating with the narrowed lumen of the ectal portion through a pore in a vertical groove on the median face of a dorsally directed, shortly conical papilla. Diverticular stalk shorter than the ovoidal to ellipsoidal seminal chamber. Genital marking glands sessile on the parietes.

Distribution.—Lyallpur, Mian Mir, Lahore, Ludhiana, Hoshiarpur, Jullundur, Phagwara, Ferozepore, Kalka, Punjab; Ajmere and Udaipur,

Rajputana; Dehra Dun, Saharanpur, Allahabad, Agra, Lucknow, Bindraban, United Provinces; Kierpur, Pusa, Bihar; Calcutta, Dattapakur, Khulna, Bongaon, Bhagalpur, Purneah, Dhalla, Netracona (Mymensing district), Raniganj (Burdwan district), Rajshahi, Saraghat, Comillah and Rangamati (Chittagong district), Bengal; Bombay and Baroda, Bombay Presidency; Gwalior, Central India. Outside of India: Burma (widely distributed, but absent from the western hills and the Shan Plateau), Andaman Islands, Siam, French Indo-China, the Malay Peninsula, Java, Sumatra, Philippines, Celebes, Christmas Island, Groot Bastaard, Ternate, New Hebrides, Santa Cruz Is., Amboine, Nias, Flores, Sebesi, Sumba, Nice (? France). (Recorded once from the Bahamas but never confirmed. According to Bahl, 1936, p. 8, found in Ceylon but no record of this can be found.)

Pheretima robusta (Perrier).

1872. *Perichaeta robusta*, E. Perrier, *N. Arch. Mus. Paris*, VIII, p. 112. (No type designation. Types from Mauritius and Manila, in the Paris Museum.)

1925. *Pheretima himalayana*, Stephenson, *Proc. Zool. Soc. London*, 1925, p. 893. (Type locality, Darjiling, India. Type in the British Museum.)

1934. *Pheretima robusta*, Gates, *Rec. Ind. Mus.* XXXVI, p. 264.

Diagnosis.—Quadrithecal, spermathecal pores minute and superficial, two pairs, on 7/8-8/9. Male pores minute and superficial, each on a small, transversely elliptical tubercle surrounded by several concentric furrows. Genital markings small, circular to elliptical tubercles, about 1 intersetal interval wide: on xviii presetal and postsetal, slightly median to the male pore lines (slightly lateral to the midventral line); presetal and postsetal on vii-viii, slightly median to the spermathecal pore lines; on the spermathecal porophores, just behind the spermathecal pores. Setae: viii/19-31, xvii/24-31, xviii/18-24, xix/23-31, 34-40/iii, 50-53/viii, 54-59/xii, 63-70/xx. First dorsal pore on 11/12. Length, 120-140 mm. Diameter, 5-8 mm. Segments, 106.

Intestinal caeca simple but with short lobes on the ventral margins. Testis sacs unpaired and ventral. Spermathecal diverticulum with spheroidal to ellipsoidal seminal chamber usually shorter than the slender stalk. Genital marking glands stalked and coelomic.

Distribution.—Darjiling in the Eastern Himalayas. Outside of India: Burma (northern portion of the Shan Plateau only, at Namkham, Kutkai and Lashio), China (Provinces of Fukien, Szechuan, Chekiang, Kiangsu, Kiangsi and Hupei, also Hongkong), Philippines (?), Mauritius (?), Madagascar (?), West Indies (?).

Pheretima taprobanae (Beddard).

1892. *Perichaeta taprobanae*, Beddard, *Proc. Zool. Soc. London*, 1892, p. 163. (Type locality, Ceylon. Types in the Oxford University Museum and the British Museum ?).

1929. *Pheretima taprobanae*, Aiyer, *Rec. Ind. Mus.* XXXI, pp. 15 and 72.

Indian specimens have not been available for study. Material in the British Museum has been examined and the account will be published elsewhere.

Diagnosis.—Bithecal, spermathecal pores minute and superficial, one pair, on the anterior margin of viii. Male pores minute and superficial, each on an indistinctly demarcated, circular, postsetal porophore. Genital markings small, circular, presetal, paired, on vi-xi and xviii-xxii. Setal circles present on all clitellar segments: viii/34-41, xvii/20-25, xviii/14-19, xix/19-25, 70/v, 77/x. First dorsal pore on 12/13. Length 80-145 mm. Diameter 4-7 mm. Segments 95-122.

Septum 8/9 present but membranous. Hearts of x and xiii lacking. Testis sacs unpaired and annular; seminal vesicles included. Spermathecal diverticulum with spheroidal to ovoidal seminal chamber and slender muscular stalk that passes into the anterior face of the duct at the parietes. Genital markings slight epidermal thickenings without internal glands.

Distribution.—Trivandrum, Travancore. Outside of India has been found in Ceylon, Madagascar and Brazil but is quite unknown from (or at least unrecognized within) the *Pheretima* domain.

APPENDIX TO THE GENUS *PHERETIMA*.

The reference listed below cannot be placed in any of the synonymies.

1917. *Pheretima hawayana*, Stephenson, *Quart. J. Mic. Sci.* LXII, pp. 260 and 267. (Pharyngeal glands.)
1918. *Pheretima hawayana*, Thapar, *Rec. Ind. Mus.* XV, pp. 69 and 71. (Blood glands.)
1919. *Pheretima hawayana*, + *P. barbadensis*, Bahl, *Quart. J. Mic. Sci.* LXIV, pp. 103 and 104. (Nephridia.)
1919. *Pheretima hawayana*, Stephenson and Ram, *Trans. Roy. Soc. Edinburgh*, LII, pp. 436, 438 and 439. (Prostates.)
1919. *Pheretima hawayana*, Stephenson and Prashad, *Trans. Roy. Soc. Edinburgh*, LII, pp. 457 and 460. (Calciferous glands.)
1924. *Pheretima hawayana*, Stephenson, *Proc. Roy. Soc. London*, B. XCVII, pp. 179 and 192. (Blood glands.)

Stephenson did not distinguish between *hawayana* and *morrisi*, now recognized as specifically distinct, and often gave no clues that would enable recognition of his forms. The material involved apparently has not been preserved. For the present at least, the proper disposition of *P. hawayana* and *P. barbadensis* of the authors and dates just cited is impossible.

1889. *Perichaeta houlleti*, Bourne, *J. Asiatic Soc. Bengal*, LVIII, p. 111.

Figure 5, pl. 3, shows a "spermatheca seen turned forwards". Presumably then it is the posterior face of the spermatheca that is drawn. Since a stalked gland is shown passing to the posterior face the worm hitherto could have been referred to *campanulata*. With the finding, as an occasional abnormality (*vide* p. 204) of posterior glands passing to the spermathecal pore invaginations, identification is no longer possible unless information with regard to other characteristics is available. Since Bourne's specimens have not been preserved and in the absence of the necessary information the reference, at least for the present, cannot be properly placed.

1886. *Perichaeta burliarensis*, Bourne, *Proc. Zool. Soc. London*, 1886, p. 667. (Type locality, Burliar, Nilgiris, S. I.)
1895. *Perichaeta burliarensis*, Beddard, *Monog.* p. 403.
1900. *Pheretima burliarensis*, Michaelsen, *Das Tierreich*, X, p. 258.
1909. *Pheretima burliarensis*, Michaelsen, *Mem. Ind. Mus.* I, p. 110.
1910. *Pheretima burliarensis*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX, (5), p. 11.
1923. *Pheretima burliarensis*, Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 297.

This species, if a *Pheretima*, is quite unrecognizable. The only evidence for recognition as a *Pheretima* is the presence of the gizzard in x, and the presence of intestinal caeca in xxvi. Equally good evidence against recognition is the inclusion of segment xvii in the clitellum and the presence of two pairs of groups of enlarged setae on vii and viii. The supposed location of the gizzard in x cannot be considered as important evidence. In the same paper Bourne incorrectly placed the gizzard of his *P. stuarti* also in x. The location of the gizzard of *P. lawsoni* and *P. hulikalensis* is probably also incorrect.

Perichaeta lawsoni and *P. hulikalensis* Bourne 1886 are quite unrecognizable and the latter, according to Stephenson (1923, p. 290), " may be a *Megascolex*." *P. lawsoni* has the gizzard in x and intestinal caeca in xxvi. Bourne failed to mention the gizzard of *hulikalensis* and evidently had some doubt as to the caeca, " I believe intestinal diverticula are present in the usual position." Both species have a clitellum that includes segment xvii. Little is known of the earthworms of the Nilgiris (one species of *Megascolex* was briefly characterized by Bourne but has not been seen since). When the fauna of this region has been worked out it may be possible to refer Bourne's three species of *Perichaeta* more or less definitely to some species of *Megascolex*.

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MGIPC—M—III-8-15—9-7-37—510.

A REVIEW OF THE GENUS *LYGOSOMA* (SCINCIDAE: REPTILIA) AND ITS ALLIES.

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Since Boulenger wrote his Catalogue of Lizards in 1887, no comprehensive attempt has been made to deal with the large group of Scinks which he called *Lygosoma*. The elevation of his Subgenera, or rather Sections, to higher rank by later herpetologists has not helped the classification of the group, and in some cases has led to greater confusion. That some of the Sections, however, although they cannot be defined in clear generic terms, represent natural groups, has long been recognised. The combination of cephalic scalation, colour-pattern and form, which is to be found, for instance, in *Otosaurus* and in the well-developed species of *Lygosoma*, is quite distinct from that which obtains in *Riopa* or in *Emoia*. The well-developed members of each group appear to be a natural assemblage of species; they are capable of being defined as such, and are treated here as genera. On the other hand such groups as *Siaphos* and *Hemiergis*, which are merely assemblages, mainly of degenerate species, and not capable of being defined, have been abandoned. *Homolepida casuarinae*, the type of *Homolepida*, and three other species usually referred to *Lygosoma*, are placed in the genus *Tiliqua*. The status given to *Sphenomorphus*, *Lygosoma* (*sensu strictu*) and *Leiolopisma*, will be dealt with under their respective headings.

The ancestor of the Scinks is not known, and there is no palæontological material to help us, but we may conceive it as a somewhat clumsily built, rather long-bodied and short-legged creature. It had a scaly lower eyelid, and an ear-opening without denticulations. The body was covered with more or less equal-sized scales and there was a full complement of head-shields including an occipital. The species of *Otosaurus*, *Dasia*, *Lygosoma* and *Emoia* that we know today, with their well-developed limbs, lacertiform bodies and symmetrically arranged head-shields, are certainly not primitive, although it may be from them that the degenerate ones have been derived.

In comparison with the tremendous changes that have taken place in the body and limbs, it is remarkable how little the head-shields have been affected. Many of the degenerate forms of *Lygosoma*, with their attenuated bodies, bud-like extremities, and closed ears, still retain all the head-shields that characterize the most highly developed members of that genus. These changes, as pointed out long ago by Günther and Boulenger, have no bearing on phylogeny.

The major structural changes that can occur are as follows:—

1. *Elongation of the body.*—Slight elongation of the body has occurred in many species, but marked elongation, with the assumption of a snake-like form, *e.g.*, *Lygosoma verreauxi*, *Riopa*

(*E.*) *anchietae*, has occurred only in the genera *Lygosoma* and *Riopa*.

2. *Reduction in the size, and ultimate disappearance, of the limbs.*—Marked elongation of the body is invariably accompanied by degeneration of the limbs. In the terminal forms of *Rhodona* they have disappeared entirely. In *Lygosoma quadrupes*, in spite of their minute size and the distance which separates the anterior from the posterior pair, they are still perfectly formed and functionally useful.
3. *Changes in the tail.* Elongation and thickening of the tail, particularly of the basal part. This change is usual in those species which have marked elongation of the body, but it may occur in species in which the body is not markedly elongate, *e.g.*, *Lygosoma lesueri*, *L. monotropis*, *L.* (*E.*) *muelleri*. Compression of the tail has been described by Werner (*Lygosoma* (*Hinulia*) *compressicauda*, 1897, Australia) and by De Witte (*L.* (*Siaphos*) *compressicauda* 1933=*de wittei* Loveridge, Belgian Congo). The character, in a lesser degree, can be seen also in *Lygosoma delicatum*, *L. albertisii* and in several Ablepharids. It is best marked in the distal half of the tail, and is particularly noticeable when regeneration has occurred.
4. *Closure of the ear-opening, and degeneration of the auditory structures* has occurred in many Scinks that lead a more or less subterranean existence. The change is brought about by growth of the scales which surround the opening. The apparent punctiform opening can, by inserting a needle into it, be shewn often to be much larger than it appears at first sight. When the ear-opening is completely covered over, the tympanum and extra-columellar structures are lost; the columella auris remains and is attached by a rod or tube of tissue to the skin. Its position is usually indicated externally by a depression.
5. *Degeneration of the eye and its coverings* has occurred only in markedly degenerate species that have taken to a fossorial life, *e.g.*, *Rhodona anguinoides*.
6. *Closure of the palatal notch* so that it lies farther back in the mouth. All the species that I have examined in which there is great elongation of the body shew this change.
7. *Increase in the size of the frontal shield and, in consequence, separation and reduction in the size of the prefrontals, which may ultimately be united with it.* The steps by which this change takes place can be studied best in *Lygosoma*, *s. s.* in its passage from *Sphenomorphus*.
8. *Enlargement of the body scales.*—The change has been brought about by (1) the union of two scales, or (2) apparent growth of one scale and suppression of the one adjacent to it. The change is best studied on the neck or at the base of the tail. Enlargement, usually in a transverse direction, of the dorsal scales, has taken place in many species. In those

which have marked reduction (18 to 22) in the number of scale-rows round the body, the scales are of uniform size throughout.

9. *Changes in the head shields.*—Fragmentation of the head-shields, as it has occurred in the Lacertidae has not taken place in the Scincidae. All the evidence that can be acquired from the degenerate forms indicates that the changes which have occurred have been in the opposite direction, namely in reduction in the number of shields by the union of two or more. I have assumed that such shields once lost, have not been regained.

   The loss of the supranasals by union with the nasals and the union of the fronto-parietals and the interparietal into a single shield, has occurred again and again in species which in all other respects are highly developed.

10. *The successive steps by which the transparent " window " in the lower eyelid has been formed from the scaly lid* is already well known. It is best seen in the Leiolopismids, and as far as the Scincidae are concerned, culminates in *Ablepharus*, under which heading it is also discussed.

11. *Changes in the digits.*—The digital characters of the species, particularly of those which affect the hind foot, have received but little attention. Like the changes that have occurred in the other parts of the body they have no bearing on phylogeny, but are of interest from an ecological point of view. Four types of modification can be recognised.

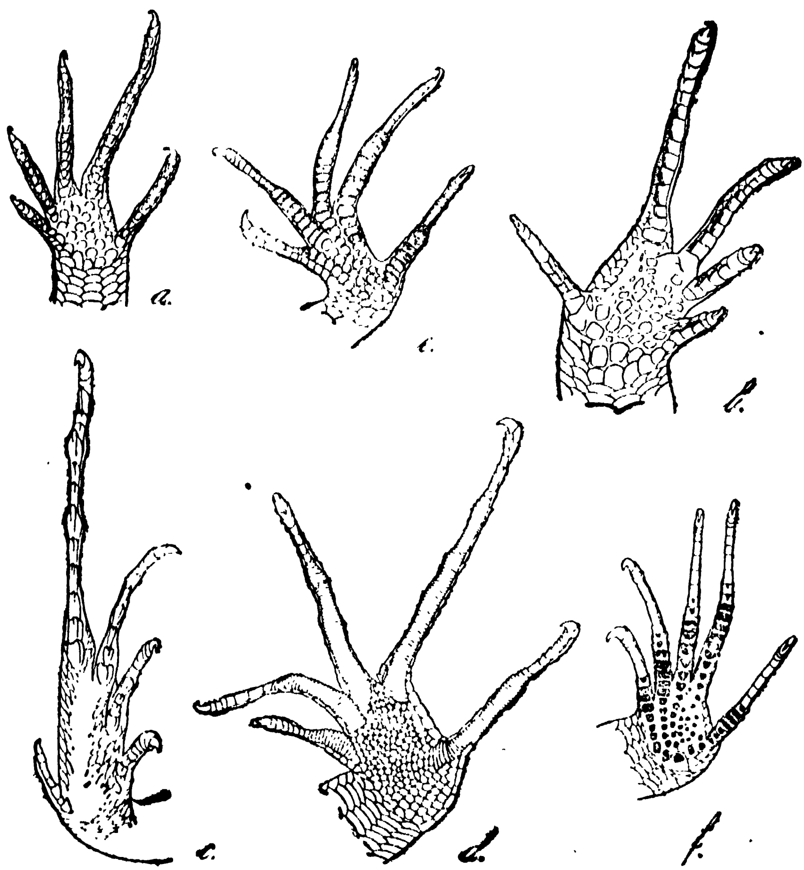
1. The simplest and least specialised form is shown in figure 1*a* (*Lygosoma indicum*), the subdigital lamellae being simply rounded or slightly keeled. It is the commonest form and occurs in the majority of species of *Lygosoma*, in *Riopa*, and with a few exceptions in all degenerate forms.

2. Figure 1*b* (*Otosaurus mimikanum*). The distinctive feature is a prominent ridge upon the lower aspect of the toes. It appears to have been formed by longitudinal division of the keeled lamellae and then increased growth of the inner portion ; it is most marked upon the third and fourth toes. This type of modification occurs also in *Lygosoma melanopogon*, *L.* (*E.*) *muelleri*, *L.* (*E.*) *pratti* and others. A similar modification can be seen in the hind feet of many of the Agamidae and Lacertidae.

3. Figure 1*c* (*Otosaurus anomalopus*). The fourth toe is greatly elongated and the subdigital lamellae are very strongly keeled, those beneath the articulations being also much larger than the others. In *anomalopus* this type of foot reaches its greatest development ; it can be seen also, though to a lesser degree, in *Otosaurus granulatum*, *O. sarasinorum*, *Lygosoma scotophilum*, *L. sanctum* and *L. maculatum*.

4. This type is characterized by enlargement of the subdigital lamellae upon the basal phalanges of the toe, and subsequently, as specialization proceeds, modification in the structure of those lamellae and differentiation of them from the lamellae upon the terminal phalanges (figure 1*d* *Emoia sanfordi*, figure 1*e* *Lygosoma anolis* and figure 1*f*

Dasia vittata). Many of the species which have these enlarged lamellae shew also that peculiar brown or black pigmentation upon the plates which can be seen in some species of Ground-Gecko (*i.e.*, *Gymnodactylus frenatus*, *Cnemaspis littoralis*), and which is associated with the proliferation of the epithelial cells and appears to be the forerunner of the hair-like processes that are characteristic of the true adhesive digit. In *Logosoma anolis* these hair-like structures have actually appeared.



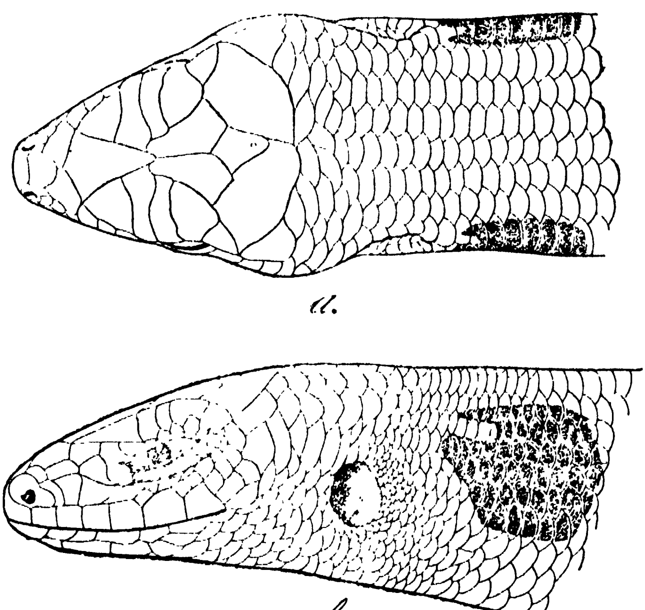
TEXT-FIG. 1.—Hind foot of *a. Lygosoma indicum. b. Otosaurus mimikanum. c. Otosaurus anomalopus. d. Emoia sanfordi. e. Lygosoma anolis. f. Dasia vittata.*

Our knowledge of the habits of the Scinks which have developed this type of foot is scanty, but many of them lead a more or less arboreal existence, an exception being *Emoia atrocostata* which lives on stones and rocks by the sea-shore. The modification is no doubt the earliest stage in the evolution of the adhesive digital disc which has attained so high a degree of development in the Geckonidae, and to a less extent in some Iguanids (*Anolis*). In the Scinks it is not yet sufficiently developed to enable them to make proper use of it as an adhesive structure. None of them appear to be able to climb a perfectly smooth surface as can most of the Geckoes and many of the Anoles.

Loss of the first finger has occurred in a large group of Leiolopismids (Section III). There are no species shewing the gradual disappearance of the digit; either it is there fully developed, or it has been lost, although dissection will usually show a vestige of the metacarpal remaining.

As already stated the purpose of this paper is to show generic relationships and to endeavour to trace the degenerate forms in each group as far as possible. In consequence the validity of species, except in a few instances, has not been questioned. The key characters under which the lists are arranged are intended primarily to indicate lines of descent rather than means of identification. Terms which apply to length of body and limb, size of ear, etc., can be approximate only, and may vary with the individual or in accordance with age.

Under *Otosaurus*, *Dasia*, *Emoia*, *Riopa* and *Rhodona* are listed all the species which appear to be valid for those genera. Those marked with an asterisk have not been seen by me. The species of *Lygosoma* are too numerous to be dealt with the same way, and only those in the British Museum collection have been mentioned.



a.

b.

TEXT-FIG. 2.—Upper (*a*) and side view (*b*) of head of *Otosaurus concinnatum* (B. M. 1932, 12.14.32-33).

The original manuscript of this article was destroyed by fire on the train in India. The carbon copy retained in London did not include all the final changes and these have been added from memory. It is hoped that the article as now presented is in the same form as the original one.

Genus **Otosaurus** Gray.

Otosaurus Gray., *Cat. Liz. Brit. Mus.*, I, 1845, p. 93 (type *cumingi*).
Parotosaurus Boulenger, *Trans. Zool. Soc. London*, XX, 1914, p. 257 (type *annectens*).

Supranasals present; fronto-parietals and interparietal distinct; ear-opening usually very large, without auricular lobules, tympanum not deeply sunk; lower eyelid scaly; limbs well developed, pentadactyle.

Range.—Malaysia to New Guinea; Celebes and the Philippines.

The separation of *Otosaurus* from *Lygosoma* rests entirely upon the presence or absence of supranasal shields. The distinction is slim, but it is a convenient means of separating from the main body of *Lygosoma* a group of species which have a number of characters in common and which are undoubtedly derived from the same stock. They are closely related to the *melanopogon-maculatum* group which, in the absence of supranasals, are placed under *Lygosoma*. In *O. concinnatum* the supranasals may be present or absent.

I. Supranasals large, in contact with one another; 6 or 7 supraoculars.

cumingi Gray	Philippines
celebense Müll.	Celebes

II. Supranasals small, widely separated from one another.

A. 6 or 7 supraoculars.

sarasinorum Blgr.	Celebes
annectens Blgr.	New Guinea

B. 5 or 6 supraoculars.

granulatum Blgr.	New Guinea
nigrilabre Günth.	Celebes
simum Sauvage	New Guinea
amblyplacodes Vogt	New Guinea
tropidonotus Blgr.	Celebes
variegatum Peters	East Indies
kinabaluense Bartlett	Borneo
llanosi Taylor	Philippines
mimikanum Blgr.	New Guinea

C. 4 (5) supraoculars.

jobiense Meyer	Papuasia
concinnatum Blgr.[1]	Solomon Is.
curtirostris Taylor	Philippines
murudensis M. A. Smith	Borneo
anomalopus Blgr.[2]	Sumatra; ? Penang

[1] Supranasals present or absent.
[2] Originally described from Penang, the species has not since been obtained in the Malay Peninsula.

Genus **Lygosoma** Hardw. & Gray.

(Section *Sphenomorphus.*)

Sphenomorphus Fitzinger, *Syst. Rept.*, 1843, p. 23 (type *melanopogon* Dum. & Bib.).
Eulamprus Fitzinger, *l.c.s.*, p. 22 (type *Lquoyi*).
Hinulia Gray., *Cat. Liz. Brit. Mus.*, 1845, p. 22 (type *Lyg. quoyi* Dum. & Bib.).
Lissonota (not of Gravenh. 1829), Blyth, *Journ. Asiat. Soc. Bengal,* XXII, 1853, p. 653 (type *maculata*).

(Section *Lygosoma.*)

Lygosoma Hardw. & Gray, *Zool. Journ.*, III, 1827, p. 228 (type *serpens*= *quadrupes*).
Siaphos Gray, in *Griff. Anim. King.*, IX, 1831, Syn. p. 72 (type *aequalis*).
Peromeles Wiegmann, *Herp. Mex.*, 1834, p. 11 (subst. name for *Siaphos*, same type).
Anomalopus Dumeril, *Cat. Meth. Rept.*, 1851, p. 185 (type *verreauxi*).
Coloscincus Peters, *Mon. Akad. Berlin*, 1876, p. 532 (type *truncatus*).

I am unable to find any character by which to separate generically the well-developed forms of *Lygosoma*, usually called *Sphenomorphus*, from the degenerate ones called *Lygosoma, sensu stricto.* Between the extremes in each Section the difference is enormous, but the gap can be bridged by connecting forms showing every stage of development. As arranged here they form a descending series in degeneration, and the two Sections are introduced merely to facilitate description and recognition. The *lesueuri-strauchi*, and the *monotropis-fasciolatum* groups, are divergents from the main line of descent, which continues on from *stellatum* through *undulatum*. Section *Leiolopisma* is dealt with separately.

Range.—The Western Pacific Islands, Australasia, Papuasia, the Oriental Region, Africa, N. America.

(Section *Sphenomorphus.*)

Supranasals absent; eyelids well developed, the lower scaly; prefrontals, fronto-parietals and interparietal distinct; limbs more or less well developed, pentadactyle; ear-opening present or absent; frontal not broader than the supraocular region.

I. The length of the leg exceeds the distance between the arm and the tip of the snout.

A. Ear-opening without lobules.

a. Normally 5-7 supraoculars.

melanopogon Dum. & Bib.	Papuasia
scotophilum Blgr.	Malaysia
aignanum Blgr.	New Guinea
lousiadense Blgr.	Louisiade Archipelago
striolatum Weber	Flores Islands
maindroni Sauvage	New Guinea
florense Weber	Flores-Timor Islands
dussumieri Gray	Southern India
maculatum Blyth	Indo-China
sanctum Dum. & Bib.	Malaysia
acutum Peters	Philippines

b. 4 supraoculars.

jagori Peters	Philippines
tersum M. A. Smith	Siam
indicum Gray	Indo-China
presigne Blgr.	Malay Peninsula
quoyi Dum. & Bib.	Australia
tenue Gray	Eastern Australia
stellatum Blgr.	Malay Peninsula ; Annam

B. Ear-opening with very distinct lobules anteriorly ; nasals large, in contact with or just separated from one another ; tail long and thick at the base. Dorsal scales larger than laterals ; 4, sometimes 5, supraoculars.

lesueuri Dum. & Bib.	Western Australia
dorsale Blgr.	New Guinea
leae Blgr.	Central Australia
taeniolatum Shaw	Australia
labillardiri Gray	Western Australia
fischeri Blgr.	Australia
ocelliferum Blgr.	Western Australia
strauchi Blgr.	Queensland

II. The length of the leg equals the distance between the arm and the tip of snout.

A. Dorsal scales obtusely keeled, forming continuous lines.

monotropis Blgr.	Australia
richardsoni Gray	Western Australia
fasciolatum Günth.	Australia

B. Dorsal scales smooth or nearly so.

undulatum Ptrs. & Doria	Papuasia
rufum Blgr.	Aru Islands
minutum Meyer	New Guinea
nigrolineatum Blgr.	,,
pallidum Günth.	Western Australia
isolepis Blgr.	Australia
pardalis Macleay	New Guinea ; Northern Australia
ornatum Gray	New Zealand
malayanum Doria	Malaysia
emigrans Lidth de J.	Sumba—New Guinea
modigliani Blgr.	Mentawei Islands
shelfordi Blgr.	Borneo
cameronicus M. A. Smith	Malay Peninsula
taprobanense Kelaart	Ceylon
striatopunctatum Ahl.	,,
fallax Peters	,,
decipiens Blgr.	Philippines
deplanchi Bavay	New Caledonia

III. The length of leg is less than distance between arm and the tip of the snout.

A. Ear-opening very distinct.

temmincki Dum. & Bib.	Sumatra—Celebes
alfredi Blgr.	North Borneo
antoniorum M. A. Smith	Timor
forbesi Blgr.	New Guinea
courcyanum Annand.	Assam
helenae Cochran	Siam
textum Müll.	Celebes
brevipes Bttgr.	,,
steeri Stejneger	Philippines
atrigularis Stejneger	,,
biparietalis Taylor	,,
vigintiserium Sjostedt	Fernando Po
australe Gray	Western Australia

B. Ear-opening punctiform or covered with scales.

luzonense Blgr.	Philippines
scutirostrum Peters	Eastern Australia
cophias Blgr.	Malay Peninsula

(Section *Lygosoma.*)

IV. Body elongate, the distance between the tip of the snout and the arm being from 2 to 4 times in the distance between the axilla and groin. Limbs short or vestigial. Frontal usually broader than the supraocular region.

A. Digits 5-5 ; ear-opening small or punctiform.

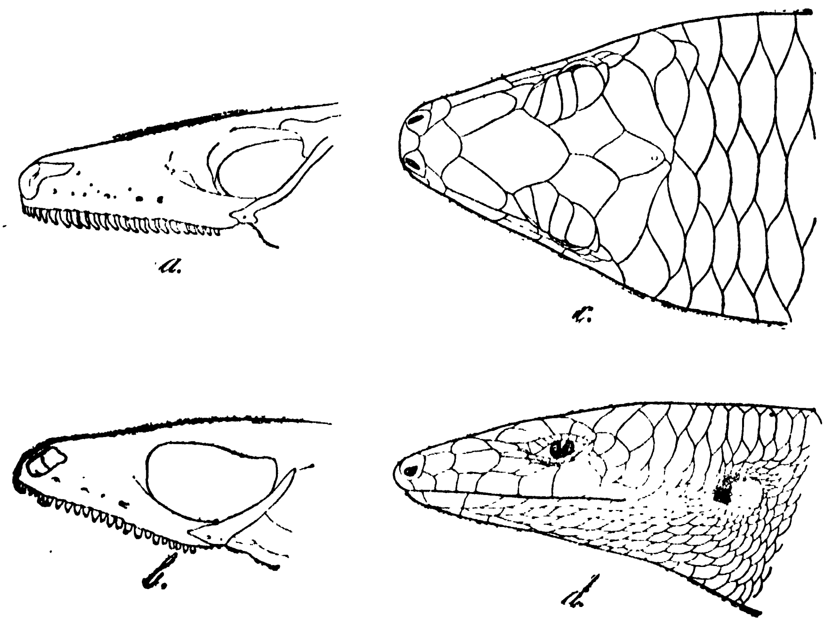
pumilum Blgr.	North Queensland
punctulatum Peters	Queensland
mjobergi Lonnb.	North Queensland
graueri Sternfeld	East Africa
quadrupes Linn.	Indo-China ; Malaya

B. Digits reduced in number ; ear punctiform or covered with scales.

aloysi-sabaudae Peracca	East Africa
meleagris Blgr.	Tanganyika Territory
clathrotis Blgr.	Kenya
aequale Gray	Western Australia
miodactylum Blgr.	Malay Peninsula
sumatrense Blgr.	Sumatra
reticulatum Günth.	New South Wales
larutense Blgr.	Malay Peninsula
verreauxi Dum.	Eastern Australia
truncatum Peters	Queensland

Lygosoma (Ictiscincus).

Elania (not of Sundevall) Gray, *Cat. Liz. Brit. Mus.*, 1845, p. 80 (type *Scincus muelleri* Schleg.).
Ictiscincus[1] nom. nov. for *Elania* preocc.



TEXT-FIG. 3.—*a.* Teeth of *Lygosoma* (*Ictiscincus*) *muelleri*. *b.* Teeth of *Lygosoma indicum*. *c-d.* Upper and side views of head of *Lygosoma* (*Ictiscincus*) *muelleri* (B. M. 1913, 10.10.173).

Teeth fang-like in the larger species. Frontal broader than the supraocular region, in contact with the enlarged first supraciliary. Body stout, somewhat elongate, limbs short, pentadactyle, tail thick. Ear-opening moderate, tympanum sunk.

Connects with *Lygosoma* through the *rufum-undulatum* group. With the exception of *crassicauda* and *woodfordi*, a group of closely related species.

muelleri Schleg.	New Guinea
pratti Blgr.	,,
woolastoni Blgr.	,,
loriae Blgr.	,,
oligolepis Blgr.	,,
solomonis Blgr.	New Guinea ; Solomon Islands
crassicauda Dum.	Papuasia ; Queensland
woodfordi Blgr.	Solomon Islands

[1] *Ictis*=a weasel.

(Section *Leiolopisma.*)

Tridactylus (not of Latreille 1802) Cuvier, *Regné Anim.*, 1829, p. 64 (type *decresiensis*).
Tetradactylus (not of Merrem 1820) Cuvier, *l. c. s.*, p. 64 (type *decresiensis*).
Peromelis Wagler, *Nat. Syst. Amphib.*, 1830, p. 160 (substitute name for *Tetradactylus* Cuvier).
Hemiergis Wagler, *l. c. s.*, p. 160 (substitute name for *Tridactylus* Cuvier); Boulenger, *Cat. Liz. Brit. Mus.*, III, 1887, p. 223.
Leiolopisma Dum. & Bib., *Erp. Gen.*, V, 1839, p. 742 (type *Scincus telfairii*).
Chelomeles Dum. & Bib., *l. c. s.*, p. 774 (type *C. quadrilineatus*).
Heteropus (not of Beauvois 1805) Dum. & Bib., *l. c. s.*, p. 742 (type *Lygosoma fuscum*).
Lampropholis Fitzinger, *Syst. Rept.*, 1843, p. 22 (type *Lyg. guichenoti*).
Eulepis Fitzinger, *l. c. s.*, p. 22 (type *Lyg. duperreyi*=*trilineatum*).
Lipinia Gray, *Cat. Liz., Brit. Mus.*, 1845, p. 84 (type *L. pulchella*).
Mocoa Gray, *l. c. s.*, p. 80 (type *guichenoti*).
Oligosoma Girard, *Proc. Acad. Philad.*, 1857, p. 196 (type *Mocoa zeylandica*=*moco*).
Hombronia Girard, *l. c. s.*, p. 196 (type *fascicolaris*).
Lygosomella Girard, *l. c. s.*, p. 196 (type *aestuosa*).
Cyclodina Girard, *l. c. s.*, p. 195 (type *aenea*).
Cophoscincus Peters, *Mon. Akad. Berlin*, 1867, p. 19 (type *quadrivittata*).
Anotis Bavay, *Mem. Soc. Linn., Normandie*, IV, 1869 (5), p. 29 (type *marei*).
Nannoscincus Günther, *Ann. Mag. Nat. Hist.*, (4) X, 1872, p. 421 (type *N. fuscus*=*marei*).
Lioscincus Bocage, *Journ. Acad. Sci. Lisbon*, XV, 1873, p. 328 (type *steindachneri*=*tricolor*).
Tropidoscincus Bocage, *l. c. s.*, p. 230 (type *aubrianus*).
Sauroscincus Peters, *Sitz. Ges. Nat. Fr. Berlin*, 1879, p. 149 (type *braconnieri* = *variabile*).
Lygisaurus de Vis, *Proc. Roy. Soc. Queensland*, I, 1884, p. 77 (type *foliorum* =*mundus*).
Myophila de Vis, *l. c. s.*, p. 77 (type *vivax*= ? *blackmanni*).

Under *Leiolopisma* are included a number of species that cannot clearly be assigned to any genus. All agree in having an undivided, more or less transparent disc in the lower eyelid, a character that from a generic point of view is worthless, as it is in *Mabuya*, *Riopa*, *Scelotes*, *Sepsina* and others. The successive steps in the transformation of the scaly lid into one having a disc can be traced in numerous species. Usually there is no difficulty in deciding which character is present, but in some species, *e.g.*, *L. ornatum*, *L. reevesi*, both conditions can be found.

The majority of the Leiolopismids have no doubt been derived from *Lygosoma* by the simple change in the eyelid, others from *Emoia* by loss of the supranasal shield through fusion with the nasal. The arrangement in the present list is based partly upon easily determined characters, partly upon geographical distribution.

I. Fronto-parietals paired (except in *novae-guineae*); interparietal large.

A. Subdigital lamellae not transversely enlarged.

a. Limbs well developed, pentadactyle; ear-opening large or moderate.

grande Gray	New Zealand Archipelago
lineo-ocellatum Dum.	,,
suteri Blgr.	,,
aeneum Girard	,,
smithi Gray	,,
homalonotum Blgr.	,,
moco Dum. & Bib.	,,
dendyi Blgr.	,,

entrecasteauxi Dum. & Bib.	Australia ; Tasmania
mustelinum O'Shaughn.[1]	,,
lichenigerum O'Shaughn.	New South Wales
infrapunctatum Blgr.	Western Australia
challengeri Blgr.	Queensland
nigrofasciolatum Peters	New Caledonia
nototaenia Blgr.	New Guinea
noctua Less.	,,
himalayana Günth.	Himalayas
ladacense Günth.	,,
sikkimense Blyth	,,
doriae Blgr.	Burma
bilineatum Gray	Southern India
laterimaculatum Blgr.	,,
vittigerum Blgr.	Indo-China ; Malaya
reevesi Gray	China ; Indo-China
unicolor Harlan	U. S. A.
rupicola M. A. Smith	Siam
telfairi Desjard	Mauritius

b. Body elongate, limbs short, not meeting when adpressed ; digits 5-5 or reduced in number ; ear punctiform or covered with scales.

peroni Fitz.	Australia
maccoyi Luc. & Frost	Eastern Australia
woodwardi Luc. & Frost	Western Australia
quadrilineatum Dum. & Bib.	,,
decresiense Fitz.	Australia
scharffi Blgr.	Queensland
gracile Bavay	New Caledonia
mariae Bavay	,,

B. Lamellae beneath the basal phalanges transversely enlarged and differentiated from those on the terminal phalanges (except in *pulchellum*).

a. Snout subacuminate ; prefrontals separated from one another ; tail ? prehensile.

elegans Blgr.	New Guinea
semoni Oudeman	,,
flavipes Parker	,,
parkeri M. A. Smith	,,

b. Snout acuminate ; prefrontals in broad contact with one another.

anolis Blgr.[2]	Solomon Islands
longiceps Blgr.	New Guinea
pulchellum Gray	Philippines

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[1] *Lygosoma* (*Leiolopisma*) *pseudotropis* Werner 1903 (type in Natural History Museum, Brussels), is identical with this species.

[2] *Lygosoma virens* (Peters) from Papua with 34-36 scales round the body and 13-14 lamellae beneath the 4th toe, is a race of *L. anolis* which has 36-40 scales round the body and 15-17 lamellae beneath the toe.

II. Fronto-parietals united; interparietal usually large; limbs pentadactyle, usually well developed.

A. Ear-opening present.

ocellata Gray	Tasmania
pretiosum O'Shaughn.	,,
trilineatum Gray	Australia; Tasmania; W. Pacific Islands
guichenoti Gray	Australia
metallicum O'Shaughn.	W. Pacific Islands
delicatum Werner	Queensland
variable Bavay	New Caledonia
steindachneri Bocage	,,
tricolor Bavay	,,
euryotis Werner[1]	,,
novae-caledoniae Parker	,,
austro-caledonicum Bavay	,,
stanleyanum Blgr.	New Guinea
miotis Blgr.	,,
morokanum Parker	,,
pulchrum Blgr.	,,
travancoricum Bedd.	Southern India
palnicum Boettg.	,,

B. Ear closed.

initiale Werner	Western Australia
relictum Vincig.	Sumatra
infralineolatum Günth.	Celebes; Philippines
quadrivittatum Peters	Celebes; Borneo
surdum Blgr.	Malaya

III. Frontoparietals united; interparietal small or absent; limbs usually well developed; 4 fingers and 5 toes.

nigrigulare Blgr.	New Guinea
fuscum Dum. & Bib.	Papuasia
becarrii Peters & Doria	Kei Islands
bicarinata Macleay	New Guinea
pectorale de Vis	Queensland
blackmanni de Vis	,,
mundum de Vis	,,
devisii Blgr.	,,
mundivense Browne	,,
tetradactylum O'Shaughn.	Eastern Australia
rhomboidale Peters	Queensland
maccooeyi Ram. & Ogilby	New South Wales
curtum Blgr.	New Guinea
novae-guinae Meyer	,,
spinauris M. A. Smith	Timor

[1] Doubtfully distinct from *tricolor*.

Genus **Dasia** Gray.

Dasia Gray, *Ann. Mag. Nat. Hist.*, II, 1839, p. 331 (type *olivacea*).
Lamprolepis Fitzinger, *Syst. Rept.*, 1843, p. 22 (type *Scincus smaragdinus* Lesson).
Liotropis Fitzinger, *l. c. s.*, p. 22 (type *Euprepes ernesti*—*olivacea*).
Keneuxia Gray, *Cat. Liz. Brit. Mus.*, 1845, p. 79 (type *smaragdinus*).
Apterygodon Ederling, *Nat. Tijd. Med. Ind.*, XXVI, 1863, p. 483 (type *vittata*).
Theconyx (not of Gray 1845) Annandale, *Spol. Zeyl.*, III, 1906, p. 191 (type *halianus*).

Supranasals present (except in *smaragdina* in which they are united anteriorly, or completely, with the nasal); prefrontals, frontoparietals and interparietal distinct; lower eyelid scaly; ear-opening small, tympanum sunk.

Limbs well developed, pentadactyle, the lamellae below the basal phalanges of the digits more or less expanded and differentiated from those below the terminal phalanges (fig. 1*f*).

Range.—From Southern India to the Western Pacific Islands.

As far as is known all the species are arboreal and subarboreal in their habits.

smaragdina Lesson	East Indies to W. Pacific Is.
dahlii Werner	Bismarck Archipelago
olivacea Gray	Indo-China ; Malaysia ; Philippines
subcoerulea Blgr.	South India
vittata Ederling	Borneo
nieuwenhuisi Lidth de J.	,,
vyneri Shelford	,,
grisea Gray	Malaysia ; Philippines
haliana Haly & Nev.	Ceylon

Genus **Emoia** Gray.

Eusoma (not of Germar 1817) Fitzinger, *Syst. Rept.*, 1843, p. 22 (type *lessoni*=*cyanura*).
Emoia Gray, *Cat. Liz. Brit. Mus.*, 1845, p. 95 (type *Scincus atrocostatus* Lesson).

Supranasals present, narrow, always separated from one another ; lower eyelid with an undivided transparent disc ; fronto-parietals united ; interparietal small or absent ; ear-opening never large, tympanum sunk. Limbs well developed, pentadactyle, digits long, the lamellae beneath the basal phalanges usually enlarged and differentiated from those on the terminal phalanges.

Range.—From Borneo and the Philippines to the Western Pacific Islands and North Australia.

I. Interparietal normally present.

nigra Hombr. & Jacq.	Papuasia ; W. Pacific Is.
adspersa Steindach.	Fiji and Samoan Is.
parietale Peters[1]	Borneo ; Christmas I.
speiseri Roux	New Hebrides

[1] *Lygosoma sinus* M. A. Smith is a race of this species.

atrocostata Lesson	Malaysia ; Papuasia ; W. Pacific Is.
battersbyi Procter	New Guinea
sanfordi Schmidt & Burt	W. Pacific Is.
cyanogaster Lesson	Papuasia ; W. Pacific Is. ; Queensland
samoensis Dum.	W. Pacific Is.
sorex Boettger	Helmaheira I.
ruficauda Taylor	Philippines.

II. No interparietal.

cyanura Lesson	Papuasia ; W. Pacific Is.
werneri Vogt	,,
klossi Blgr.	New Guinea
tropidolepis Blgr.	,,
baudinii Dum. & Bib.	Papuasia ; Celebes
iridescens Blgr.	,,
kukenthali Boettger	Halmaheira I.
mivarti Blgr.	W. Pacific Is.
tetrataenia Blgr.	,,

Species not seen by me.

acrocarinata Kopstein	New Guinea
ahli Vogt	,,
buergersi Vogt	,,
callisticta Peters	,,
cunieceps de Vis	,,
pallidiceps de Vis	,,
jakati Kopstein	Solomon Is.
flavigularis Schmidt	,,
mehelyi Werner	,,
murphyi Burt	,,
whiteneyi Burt	,,
similis Dunn	Flores

Genus **Riopa** Gray.

Riopa Gray, *Ann. Mag. Nat. Hist.*, II, 1839, p. 332 (type *Lyg. punctata*).

Campsodactylus Dumeril, *C. R. Acad. Sci.*, IV, 1837, p. 16 (type *lamarrei*= *vosmaeri*).

Chiamela Gray, *Ann. Mag. Nat. Hist.*, 1839, p. 332 (type *C. lineatus*).

Hagria Gray, *l. c. s.*, p. 333 (type *Scincus vosmaeri*).

Liosoma (not of Brandt 1834) Fitzinger, *Syst. Rept.*, 1843, p. 22 (type *Eumeces microlepis* Dum. & Bib.).

Sphenosoma (not of Dejean 1834) Fitzinger, *l. c. s.*, p. 23 (type *Eumeces punctatus* Wiegmann).

Eugongylus Fitzinger, *l. c. s.*, p. 23 (type *Eumeces oppelii-rufescens*).

Mochlus Günther, *Proc. Zool. Soc. London* 1864, p. 308 (type *punctulata*).

Panaspis Cope, *Proc. Acad. Philad.*, 1868, p. 317 (type *aeneus*=*cabindae*).

Eumecia Bocage, *Journ. Acad. Sci. Lisbon* III, 1870, p. 67 (type *anchietae*).

The genus, as now tentatively reconstructed, consists of four groups or subgenera, each one containing a number of species closely related to each other, but not clearly related to the species in the other groups.

Riopa (Riopa).

Supranasals present, sometimes united anteriorly with the nasals; frontal broader than the supraocular region, broadly truncate anteriorly; prefrontals usually small and widely separated; lower eyelid scaly or with a disc; ear-opening distinct; tympanum sunk; body stout, more or less elongate; limbs short.

Range.—The Oriental Region; Africa.

The depressed, cuneiform snout, which characterizes the African *sundevalli-modestum* group and culminates in *vinciguerra* is foreshadowed in the Oriental *herberti, bowringi, punctata* and *koratense.* The resemblance of *R. guineense* from W. Africa to *R. herberti* from Siam is remarkable. When a good series of each is examined it is possible to separate the African form from the Siamese in having a slightly longer body and a few more scales, counted in longitudinal series, down the back. But individuals can be found which, if the locality of origin were not known, it would be difficult to give a name to. Such a case is probably explained by great consistency within the genus rather than by parallel evolution.

I. Supranasals large, in contact with one another.

A. Lower eyelid scaly.

a. Supranasals entire, or united anteriorly with the nasals.

fernandi Burton	West Africa
mocquardi Chaban.	Central Africa
bampfyldei Bartlett	Malaya
opisthorhodum Werner*	Sumatra
corpulentum M. A. Smith	Annam
koratense M. A. Smith	Siam
albopunctatum Gray	India
bowringi Günther	Indo-China; Philippines
herberti M. A. Smith	Peninsular Siam
guineense Peters	West Africa
sundevalli A. Smith	Africa
modestum Günther	East Africa

b. Supranasals completely united with the nasals.

vinciguerra Parker	Somaliland

B. Lower eyelid with a disc.

guentheri Peters	India
punctata Gmelin	,,
lineolata Stol.	Burma
anguina Theobald	,,
lineata Gray	Bombay District
vosmaeri Gray	Bengal
mabuiformis Loveridge	Kenya Colony
tanae Loveridge	,,

II. Supranasals separated from one another; lower eyelid scaly.

producta Blgr.*	Somaliland
isodactyla Günther	Siam

Riopa (Eugongylus).

Supranasals present ; frontal not broader than the supraocular region ; lower eyelid scaly.

Range.—Papuasia ; Western Pacific Islands ; Northern Australia.

I. Supranasals in contact with one another.

garnieri Bavay	New Caledonia

II. Supranasals separated from one another.

albofasciolata Günther	Solomon Islands ; Northern Australia
microlepis Dum. & Bib.*	Friendly Islands
rufescens Shaw	Papuasia ; Northern Australia
mentovaria Boettg.*	Halmaheira
sulaense Kopstein*	Sula Islands

Riopa (Panaspis).

Supranasals small, widely separated from one another, or absent (united with the nasals) ; frontal narrower than the supraocular region ; prefrontals, fronto-parietals and interparietal distinct ; lower eyelid with a disc ; limbs short, pentadactyle.

Range.—West Africa.

Parker has shown elsewhere (*Nov. Zool.* 1936, p. 139) that the species of the *breviceps-kitsoni* group are closely related to *reichenovei* and *africanum*, species which have lost the supranasal and are usually placed under *Leiolopisma*. This view is strengthened by the discovery that in some examples of *breviceps* (B. M. 1903. 11. 12. 10-14) union of the supranasal with the nasal has actually occurred. *Ablepharus cabindae* is placed in this group, with which, in cephalic scalation, it agrees. The disc of the lower eyelid in this species is very large but closure has not taken place. The palpebral fissure is still visible externally, the upper and lower eyelids being united only at the commissures.

I. Supranasals present, sometimes united with the nasals.

A. Disc of lower eyelid moderately large.

breviceps Peters	French Congo
togoense Werner	Ashanti
kitsoni Blgr.	Gold Coast

B. Disc of lower eyelid very large.

cabindae Bocage	Angola

II. Supranasals always united with the nasal ; disc of lower eyelid very large.

reichenovei Peters	Cameroons
africanum Gray	Gulf of Guinea

Riopa (Eumecia).

Supranasals present or united with the nasal, in contact with one another ; prefrontals very large ; frontal long and narrow ; fronto-parietals and interparietal distinct ; lower eyelid with an undivided opaque disc. Body very elongate ; limbs vestigial.

Range.—East Africa.

anchietae Bocage	British East Africa
johnstoni Blgr.	Nyasaland

Genus **Rhodona** Gray.

Rhodona Gray, *Ann. Mag. Nat. Hist.*, 1839, p. 335 (type *punctata=lineopunctulata* Dum. & Bib.).
Soridia Gray, *l. c. s.*, p. 335 (type *lineata*).
Praepeditus Dum. & Bib., *Erp. Gen.* V, 1839, p. 787 (subst. name for *Soridia*).
Brachystopus Dum. & Bib., *l. c. s.*, p. 778 (type *lineopunctulatus*).
Ronia Gray, in Grey's *Trav. Austral.* II, 1842, p. 437 (type *catenulata=lineopunctulata* Dum. & Bib.).
Leptosoma (not of Nardo 1826) Fitzinger, *Syst. Rept.* 1843, p. 23 (type *bougainvillii*).
Pholeophilus Smith, *Ill. S. Africa*, 1849, p. 15 Append., (type *capensis=lineata*).
Ophioscincus Peters, *Mon. Akad. Berlin*, 1873, p. 747 (type *australis*).
Isopachys Lonnb., *Kungl. Sv. Vet. Akad. Handl.* LV, 1916, 4 p. 10 (type *gyldenstolpei*).
Typhloseps Angel, *Bull. Mus. Hist. Nat. Paris*, 1920, p. 4 (type *roulei*).

Snout more or less depressed and cunieform in shape, with projecting rostral; nasals and frontonasal very large; frontal broader than the supraocular region; prefrontals small and widely separated or absent. Ear-opening punctiform or absent. Lower eyelid with an undivided disc, except in *pumila* and *anguinoides*. Limbs very short, or vestigial or absent.

Range.—Australia; Siam. This apparently unusual distribution is paralleled by that of the agamid genus *Physignathus*.

A group of degenerate species derived perhaps from some *Riopa*-like stock. The African *Riopa vinciguerra* although possessing *Rhodona*-like characters is too obviously related to the *Riopa modesta* group to be included here. *Rhodona anguinoides*, *Rh. roulei* and *Rh. ophioscincus* which I originally placed under *Ophioscincus* (*Fauna Brit. Ind.* II, p. 333) are too intimately linked with other species of *Rhodona* to be separated from them.

I. Frontoparietals and interparietal distinct.

A. Limbs pentadactyle.

microtis Gray	Australia
pumila Blgr.	Queensland
bougainvillii Gray	Southern Australia

B. Digits reduced in number.

frosti Zeitz.	Australia
terdigitatum Parker	Australian Bight
walkeri Blgr.	Australia
gerrardi Gray	,,
punctatovittata Günther	Australia; Tasmania
fragile Günther	,,
planiventralis Luc. & Frost*	Western Australia
macropisthopus Werner*	Queensland
picturata Fry*	Western Australia
nichollsi Loveridge*	,,

C. No anterior limbs; posterior vestigial.

wilkinsi Parker	Queensland

D. Neither anterior nor posterior limbs.

anguinoides Blgr.	Siam.
roulei Angel	,,
australe Peters	Queensland

II. Frontoparietals and interparietal united ; no anterior limbs ; posterior vestigial.

A. Prefrontals present.

lineopunctulata Dum. & Bib.	Western Australia

B. No prefrontals.

bipes Fischer	Western Australia
miopus Günther	,,
lineata Gray	..

Genus **Ateuchosaurus** Gray.

Ateuchosaurus Gray, *Cat. Liz. Brit. Mus.* 1845, p. 107 (type *chinensis*).
Lygosaurus Hallowell, *Proc. Acad. Philad.*, 1860, p. 496 (type *pellopleurus*); Stejneger *Herp. Japan* 1907, p. 221.

Agrees with *Lygosoma* but no proper parietal shields, and the frontal very long and constricted, or divided, in the middle.

Range.—Tongking ; South China and the Riu Kiu Islands.

chinensis Gray	Southern China ; Tongking
pellopleurus Hallowell	Riu Kiu Islands

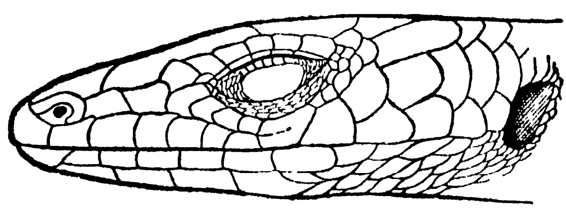
Genus **Cophoscincopus** Mertens.

Cophoscincus (not of Peters 1867) ; Vaillant, *Bull. Soc. Philom.* (7) VIII, 1884, p. 170 (type *C. simulans*= *Tiliqua dura* Cope).
Cophoscincopus Mertens, *Zool. Stuttgart,* XXXII, 1934, p. 190.

Ear-opening present, but covered, or almost entirely, with scales ; dorsal and lateral scales strongly keeled, those on the flanks arranged obliquely.

In general appearance, except for the character of the ear, like *Tropidophorus.*

A single species in West Africa.



TEXT-FIG. 4.—Side view of head of *Ablepharus spenceri.*

Genus **Ablepharus** Fitzinger.

I have recently advanced the view (*Fauna Brit. India,* II, 1935, p. 309) that *Ablepharus* is a genus of polyphyletic origin. It has been formed, not by the diversification of a single species, but by the independent evolution of a particular character, namely the covering of the eye

by the growth of the lower eyelid with its accompanying transparent disc, and the ultimate union of that lid with the upper, in a number of species in different parts of the world. The union of the two lids, however, is not so complete as is usually believed. A close examination of those structures will show that in several species, *A. boulengeri*, *A. egeriae*, *A. burnetti*, *A. pannonicus*, *A. tenuis*, the palpebral fissure still persists, but being small and hidden beneath the supercilium, or the vestige of the upper lid, has escaped observation.

A still earlier stage in the process of closure of the eye can be seen in the Australian *A. spenceri*, (fig. 4) a species in which the palpebral fissure is still visible externally, the union of the two lids having taken place only at the inner and outer commissures. *A. spenceri* was originally described as an *Emoia*, but its nearest relative is undoubtedly *A. lineo-ocellatus*. Closure of the eye in *spenceri* has not proceeded so far as in *lineo-ocellatus*, and the crescentic shield above the nasal which represents a combined supra-and post-nasal is different. In *A lineo-ocellatus*, however, both supra-and post-nasal may be present (Loveridge, *Bull. Mem. Comp. Zool., Harvard*, LXXVII, 1934, p. 377) or both may be united with the nasal. In the character of the eye, in that closure is not yet complete, *Emoia spenceri* resembles *Ablepharus cabindae*. The latter, for reasons already given, is transferred to *Panaspis*, the former is now placed under *Ablepharus*, and the definition of that genus emended accordingly (Smith, *Fauna Brit. Ind.*, II, p. 309). That the condition of the eye as seen in these two species is but a further stage in the enlargement of the lower lid with its accompanying disc, such as obtains in *Lygosoma entrecasteauxi*, *L. trilineatum*, *L. himalayanum*, *L. albertisii*, *Riopa africanum*, to name but a few in which disc is particularly large, will not be disputed.

The origin of most of the Ablepharids cannot now be traced, the changes in cephalic scutellation having made this impossible. The majority appear to have been derived from *Lygosoma* through the Leiolopismids; *A. boutoni*, the most widely distributed species has all the characters of *Emoia*; *A. spenceri* and *A. lineo-ocellatus* possess supranasal shields but they do not appear to be related in any other way to the genera that have those shields.

Genus **Tiliqua** Gray.

Tiliqua Gray, *Ann. Phil.* (2) X, 1825, p. 201 (type *gigas*).

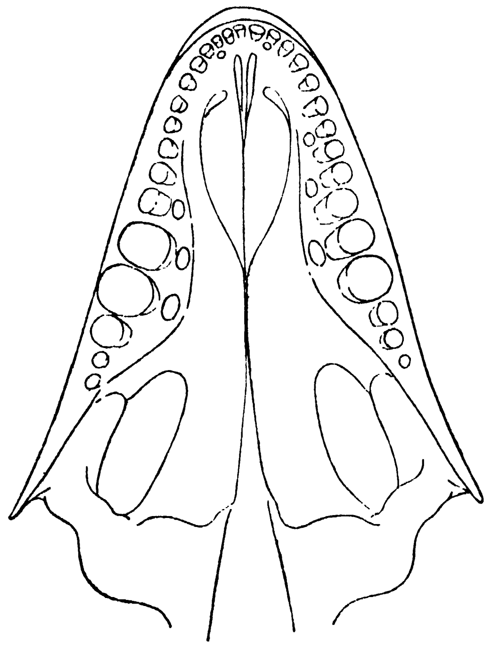
Cyclodus Wagler, *Desc. Icon. Amphib.* (1) 1828, tab. 6 and *Syst. Amphib.* 1830, p. 162 (type *flavigularis*=*gigas*).

Omolepida Gray, *Cat. Liz. Brit. Mus.*, 1845, p. 87 (type *Cyclodus casuarinae* Dum. & Bib.).

Cyclodomorphus Fitzinger, *Syst. Rept.*, 1843, p. 23 (type *Cyclodus casuarinae*).

Lateral teeth with spheroidal crowns increasing in size from before backwards, except the last two or three which are smaller. Eye-lids well developed, scaly; tympanum distinct, deeply sunk; nostril pierced in a single nasal, usually with a curved groove behind it; no supranasals; prefrontals, frontoparietals, and interparietal distinct, the last named

separating the parietals. Body more or less elongate, limbs short, pentadactyle.



TEXT-FIG. 5.—Upper jaw of *Tiliqua gigas.*

In the character of its teeth, and in having the parietals completely separated by the interparietal, *Cyclodus casuarinae* Dum. & Bib. agrees with *Tiliqua*, and its proper place is in that genus. Three other species, usually referred to *Lygosoma* or *Omolepida* are, for the same reason, placed there also. The genus with its additions, will now stand as follows :—

I. Length of tail not longer than the length of the body ; a complete series of scales between the orbit and the upper labials.

gigas Schneid.	Papuasia
scincoides White	Australia ; Tasmania
nigrolutea Gray	Australia
occipitalis Peters	Australia ; Tasmania
adelaidensis Peters	,,

II. Length of tail longer than the length of the body ; no complete series of scales between the orbit and the upper labials.

casuarinae Dum. & Bib.	Australia ; Tasmania
branchiale Günth.	,,
wood-jonesi Procter	,,
gastrostigma Blgr.	,,

Lygosoma parkeri, sp. nov.

(Section *Leiolopisma*).

Type : Brit. Mus. 1913, 11.1.57.

Distance between the snout and the fore-limb once and a third times in the distance between the axilla and groin ; snout rounded ; rostral in good contact with the fronto-nasal, which is a little broader than long ; prefrontals large, just separated from one another and united with the anterior loreal ; posterior loreal longer than high ; frontal longer than the parietals and interparietal together, its lateral margins indented by the second supraocular ; four supraoculars, first largest, three in contact with the frontal ; parietals in contact with one another behind the interparietal ; a pair of nuchals ; eight or nine supraciliaries, all higher than long ; nine supralabials, the sixth largest and subocular ; two large superposed temporals. Ear-opening oval, nearly as large as the disc of the lower eyelid, no projecting lobules.

Body scales quite smooth, the dorsals a little larger than the laterals, 36 round the middle of the body ; a pair of enlarged preanals. Tail a little longer than the head and body, covered with sub-equal scales. Limbs rather short, just overlapping when adpressed ; subdigital lamellae beneath the basal phalanges transversely enlarged, and differentiated from those on the distal phalanges : eight or nine lamellae beneath the basal phalanges of the fourth toe.

Light brown above indistinctly shaded with darker brown, and with dark brown sinuous alternating cross-bars extending from the vertebral line to the sides of the body ; tail with dark cross-bars above ; head-shields outlined with dark brown ; white below.

From snout to vent 53 m.m.

Described from a single specimen obtained by the Woolaston Expedition in 1913, on the Utakwa River, Dutch New Guinea.

L. parkeri is related to the species of the *elegans-flavipes* group ; it differs from them all in the character of the frontal and prefrontal, and in colour pattern.

CATFISHES OF THE GENUS *HELICOPHAGUS* BLEEKER.

By SUNDER LAL HORA, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta.*

It is generally recognised that the freshwater fish-fauna of India is very closely allied to that of south-eastern Asia, and, I[1] recently put forward the suggestion that it is in the main derived from that source. To elucidate the genetic affinities of some of the Indian forms it has, therefore, been necessary to study the morphological features of the related Far Eastern genera. For instance, in my work on the Siluroid fishes of India, Burma and Ceylon I found that though the accounts of the genus *Helicophagus* Bleeker clearly show its relationships to *Pangasius* Cuvier and Valenciennes, there are certain features in the anatomy of the latter by which it can be separated from the other Schilbeid fishes of south-eastern Asia and Africa; certain authorities[2] as a result regard it as a member of a separate, monotypic family Pangasiidae. The modern classification of Siluroid fishes is, in the main, based on Bridge and Haddon's[3] critical morphological studies of these fishes, especially of their air-bladder and the associated skeletal structures. Unfortunately these authors were for want of material not able to deal with all the forms of the family, and in most cases it was not possible for them to study the changes undergone during growth in various species. *Helicophagus* was one of the genera, of which they had no specimen for study, but they reported upon 5 species of *Pangasius*. Through the kindness of Mr. Luang Choola, Officer-in-charge, Bureau of Fisheries, Bangkok, I was able to obtain on loan a fine example of *H. waandersi* Bleeker for study. I have availed myself of this opportunity to examine as much of its anatomy as possible without impairing the utility of the specimen for museum purposes. I am very grateful to Mr. Luang Choola and the Bureau of Fisheries, Bangkok, for the loan of the specimen.

According to Weber and de Beaufort,[4] *Helicophagus* and *Pangasius* can be distinguished from each other with the help of the following key:—

"*a.* Posterior nostril between anterior one and eye; eye behind and totally above corner of mouth. No palatine teeth . . . . . . *Helicophagus.*

b. Posterior nostril at short distance from anterior and above a line between anterior nostril and eye. Eye partly below a horizontal through the corner of mouth . . . . . *Pangasius.*"

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[1] Hora, S. L.—Geographical Distribution of Indian Freshwater Fishes and its bearing on the probable land connections between India and the adjacent Countries. *Curr. Sci.*, V, pp. 351-356 (1937).

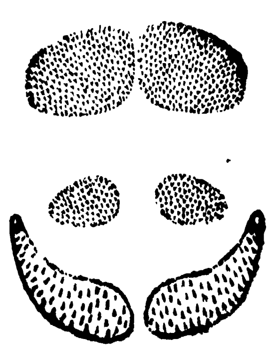
[2] Regan, C. Tate.—The classification of the teleostean fishes of the Order Ostariophysi. II. Siluroidea. *Ann. Mag. Nat. Hist.*, (8) VIII, pp. 553-557 (1911).

[3] Bridge, T. W. & Haddon, A. C.—Contribution to the anatomy of Fishes.—II. The Air-bladder and Weberian Ossicles in the Siluroid Fishes. *Phil. Trans. Roy. Soc. London*, (B) CLXXXIV, pp. 214-221 (1893).

[4] Weber, M. and de Beaufort, L. F.—*The Fishes of the Indo-Australian Archipelago.* II, p. 247 (Leiden, 1913).

In the above key no reference is made to the nature of the teeth in *Pangasius*, but in the description of the genus the authors state that the vomerine and the palatine teeth are " in 4 patches, or united into one, or only the vomerine patches united ". I have examined the dentition of several species of *Pangasius* and find it to be very variable. In species like *P. hypophthalmus* (Sauvage), the dentition is feebly developed or altogether absent. In the development of *Pangasius pangasius* (Ham.) it has been found that the dentition of the species undergoes considerable changes. In the case of *Pangasius*, therefore, dentition is not a very safe diagnostic character. Presumably on the basis of dentition alone Sauvage[1] referred *P. hypophthalmus* to the genus *Helicophagus* and the same feature appears to have influenced Suvatti[2] in supporting Sauvage's view. It has, however, been shown by me[3] that in this species the posterior nostril is situated only slightly behind the anterior and above the line joining the middle of the eye to the anterior nostril. According to this character there is no doubt regarding its position in the genus *Pangasius*. Its broad head and snout also point to the same conclusion, for in *Helicophagus* the head is conical with a prominent, bluntly-pointed snout. Moreover, a part of its eye is situated below a horizontal line passing through the corner of the mouth.

After the elimination of *P. hypophthalmus* from *Helicophagus* there only remain 2 species of this interesting genus : *H. typus* Bleeker, known from Palembang in Sumatra and *H. waandersi* Bleeker, known from Palembang, river Batang Hari and Djambi in Sumatra, Siam and Indo-China. Thus this genus has a somewhat restricted distribution, whereas *Pangasius* is found throughout south-eastern Asia (including India), except Southern China and Ceylon.



TEXT-FIG. 1.—Dentition of *Helicophagus waandersi* Bleeker. × 7. Length of specimen 143 mm. without caudal.

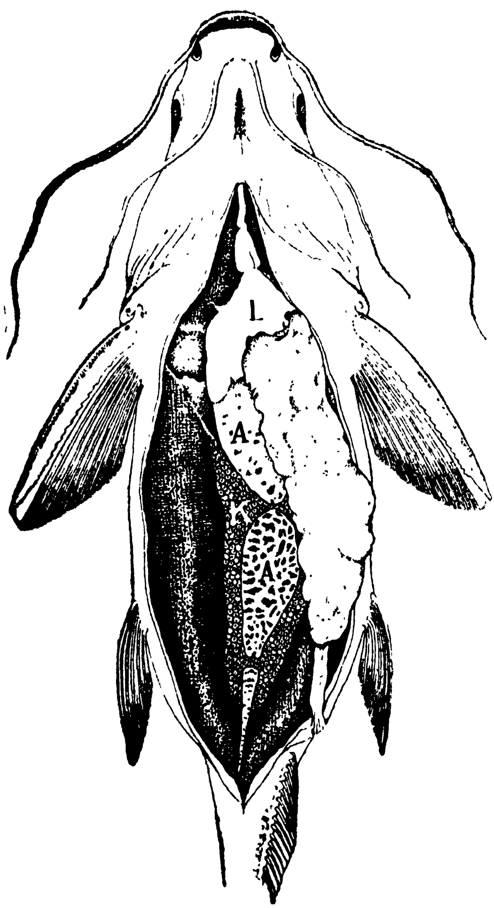
Comparing *Helicophagus waandersi* with several species of *Pangasius* that I have studied I find that the former possesses much longer barbels

[1] Sauvage, H. E.—Recherches sur la faune ichthyologique de l'Asie et description d' especes nouvelles de l'Indo-Chine. *Nouv. Arch. Mus. Hist. Nat. Paris*, (2), IV, p. 170 (1881).

[2] Suvatti, C.—*Index to Fishes of Siam*, p. 81 (Bangkok, 1936).

[3] Hora, S. L.—On a collection of fish from Siam. *Journ. Nat. Hist. Soc. Siam*, VI, p. 166 (1923).

and a very peculiar type of dentition. The teeth (text-fig. 1) of the upper jaw form two almost quadratic patches and those of the vomer are disposed in two small patches widely separated from one another. In the lower jaw the teeth are somewhat larger and fewer in number ; they form two pear-shaped patches with the points directed outwards and backwards. In *H. typus*, however, the teeth in the jaws are stated to form broad, curved bands ; while those on the vomer are arranged in two distinct, narrow, curved bands. There would thus appear to be considerable variation in the dentition of this genus.



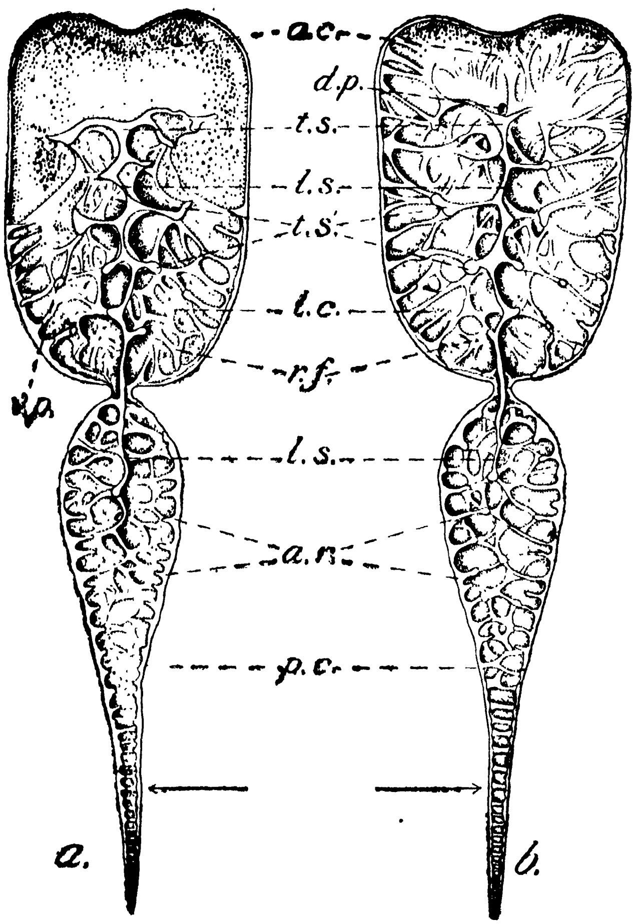
TEXT-FIG. 2.—Dissection of the visceral organs of a specimen of *Helicophagus waandersi* Bleeker. ×1½.

A. Air-bladder; **K.** Kidney; **L.** Liver.

To examine the disposition of the visceral organs of *H. waandersi* (text-fig. 2) an incision was made along the mid-ventral line. The positions of the liver, the kidneys and the air-bladder respectively were almost similar to those of *Pangasius pangasius*.[1] The lateral lobes of the liver

[1] Hora, S. L.—Correlation between the disposition of the Liver and the Kidney and the form of the Air-bladder in Certain Siluroid Fishes of India. *Proc. Nat. Inst. Sci. India*, III, p. 34 (1937).

are lodged in small cul-de-sacs above the pectoral fins, so that the liver lies very close to the skin. The air-bladder is divided into two portions, a large anterior portion corresponding to the normal air-bladder and a posterior portion which is drawn out in the form of a caecum. A small portion of the caecum extends into the muscles of the tail on the right



TEXT-FIG. 3.—Air-bladder of a specimen of *Helicophagus waandersi* Bleeker, 143 mm. in length without the caudal, showing the internal structure. ×2⅔.

a. Dorsal half; *b.* Ventral half.

a. c. Anterior chamber; *a. r.* Annular ridges; *d. p.* Pneumatic duct; *l. c.* Lateral chamber; *l. s.* Longitudinal septum; *p. c.* Posterior chamber or caecum; *r. f.* Root-like fibres; *t. s.* Primary transverse septum; *t. s.'* Secondary transverse septa; *v. p.* Vertical pillar.

The part of the air-bladder below the arrows is enclosed in the muscles of the tail region.

side. In several respects the bladder is similar to that of a specimen of *Pangasius pangasius* of the same size (143 mm. in length without caudal).

The internal structure of the air-bladder (text-fig. 3) is, in the main, similar to that of a specimen of *P. pangasius*[1] of the same size. The anterior portion of the bladder is divided internally by a primary transverse septum (*t. s.*) into a short and broad anterior chamber (*a. c.*) and a pair of lateral chambers (*l. c.*), separated from each other by a longitudinal septum (*l. s.*). The dorso-lateral walls of the anterior chamber bulge out dorsally so as to form pocket-like cavities which are lodged inside the recesses provided by the vertebral elements, one on either side of the vertebral column. The remaining portion of this chamber is invaded by fibrous growths of the primary transverse septum. The cavities of the lateral chambers are subdivided and broken up by the formation of numerous secondary transverse septa (*t. s'.*), which grow out from the sides of the longitudinal septum; they do not, however, extend to the outer wall of the chambers. In the transverse cavities thus enclosed, the walls become greatly thickened and sacculated by the development of fibrous tissue (*r. f.*) so that the free space inside the bladder is greatly reduced. In addition to these fibrous growths, there are a few vertical pillars (*v. p.*) which make the air-bladder more compact.

The pneumatic duct (*d. p.*) opens into the bladder on its ventral wall in the middle line just in front of the transverse septum.

The posterior portion of the bladder (*p. c.*) communicates anteriorly with both the lateral chambers of the anterior portion, but terminates blindly behind. It is fairly broad anteriorly but from the middle of its length becomes very narrow and tube-like. The longitudinal septum noted above, extends into the caecum for a short distance. The walls of the caecum are greatly thickened throughout by the formation of annular ridges (*a. r.*).

In the modification of the anterior vertebrae (text-fig. 4), *Helicophagus waandersi* differs from most of the species of *Pangasius*, but conforms to the normal condition in a great majority of the Siluroid fishes. Each of the transverse processes of the fourth vertebra has a broad flat root, which is prolonged distally into distinct anterior (*t.* p^4. *a.*) and posterior (*t.* p^4. *p.*) divisions, separated from each other by a broad, deep concavity. The anterior division is moderately thick and inflexible and does not possess any trace of the oval plate so characteristic of *Pangasius pangasius* and several other species of the genus. So in *Helicophagus* there is no "elastic-spring" mechanism; the distal portion of the process is applied to and firmly supports the outer extremity of the inferior limb of the post-temporal (*pt. i.*). The structures described above correspond with those of *P. micronema* Bleeker, the only species of *Pangasius* in which Bridge and Haddon (*op. cit.*) did not find an "elastic-spring" mechanism, and which would in the circumstances appear to form a connecting link between the genera *Helicophagus* and *Pangasius*.

In *P. pangasius*, Nair (*op. cit.*) has shown that with the development of the fish the space inside the air-bladder is gradually reduced and in

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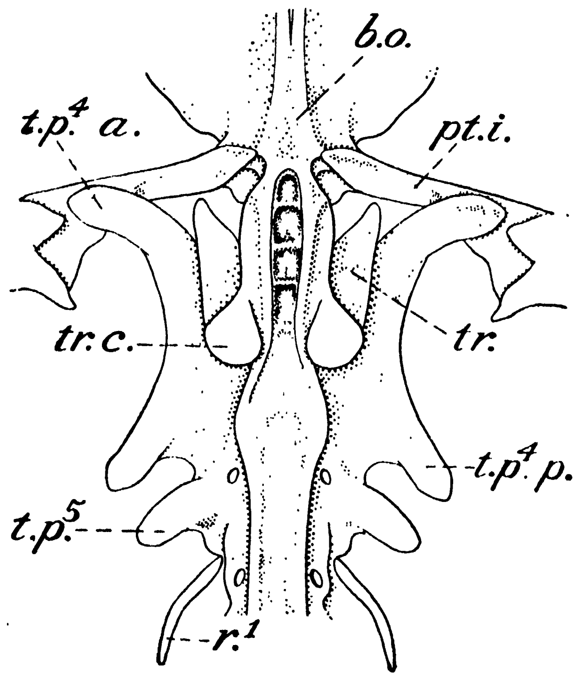
[1] Nair, K. K.—Changes in the Internal Structure of the Air-bladder of *Pangasius pangasius* (Ham.) during Growth. *Rec. Ind. Mus.*, XXXIX, pp. 117-124 (1937).

It may, however, be noted that the air-bladder of a specimen of *Pangasius pangasius*, 143 mm. in length, does not extend into the muscles of the tail region; the narrow portion of its caecum is devoid of annular ridges and the posterior portion is smaller than the anterior. The absence of an "elastic-spring" mechanism in *Helicophagus* is referred to later.

large specimens a fatty degeneration of its tissues, especially at the anterior end, takes place. So far as the hydrostatic function of the



TEXT-FIG. 4.—Ventral view of the anterior vertebrae and their processes in a specimen of *Helicophagus waandersi* Bleeker, showing the absence of any "elastic-spring" mechanism. × 4.

b. o. Basioccipital; *pt. i.* Inferior process or limb of post-temporal; r^1. First rib; *t.* p^4. *a.* Anterior division of the transverse process of the fourth vertebra; *t.* $p.^4p$. Posterior division of the transverse process of the fourth vertebra; *t.* $p.^5$ Transverse process of the fifth vertebra; *tr.* Tripus; *tr. c.* Crescentic process of the tripus.

bladder is concerned it becomes less and less effective with growth. Owing to the competition for space inside the body cavity of forms with a long anal fin, the bladder is pushed from all sides and it seems to me that the modification of the anterior division of the transverse process of the fourth vertebra to form a plate is meant to check the forward growth of the bladder. It is because of this resistance at the anterior end that the bladder finds space for its extension in the muscles of the tail. The so-called "elastic-spring" apparatus is a primitive device, while the condition met with in *P. micronema*, *Helicophagus waandersi*, and in a majority of the other Siluroid fishes is of a more specialised nature.

From the foregoing considerations it would appear that *Helicophagus*, with long barbels, well-developed dentition, without an "elastic-spring" apparatus, etc., etc., is at a somewhat higher stage of evolution than *Pangasius*. There also seems no justification for separating *Pangasius* from the rest of the Schilbeidae only because of the presence of "elastic-spring" mechanism in a number of its species.

COMPARISON OF THE FISH-FAUNAS OF THE NORTHERN AND THE SOUTHERN FACES OF THE GREAT HIMALAYAN RANGE.

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When Stewart[1] wrote a short article under the above title in the series of reports on a collection of aquatic animals made by him in Tibet during the year 1907, he was probably not aware that Day[2] had already compared in some detail the fish fauna of the highlands of Central Asia with that of the contiguous regions. In this connection Day made a survey of the fishes of Afghanistan, Western Turkestan, Eastern Turkestan, Yarkand, Tibet and Hindustan and concluded as follows (p. 25):

"The conclusion, I think, we may fairly arrive at after examining the fishes of Yarkand and the adjoining countries, is that we find a peculiar group of Carps (Schizothoracinae) which has spread almost due east and west from the cold and elevated regions of Eastern Turkestan, but of which the southern progress has been barred by the Himalayas."

"If we look to the south, we see, as it were, that a wave of tropical forms of fishes has, at a prehistoric period, expanded over that portion of the globe where the Nicobars, Andamans, and the most southern portions of the continent of Asia and the islands of the Malay Archipelago now are, that this fish fauna has its northward progress arrested by some cause at or near where the Himalayas now exist and mark the division between the fish-fauna of India and that of Turkestan."

Stewart's data for the comparison of the two faunas were based on the records of distribution of the various Indian species in Day's volumes in the "Fauna of British India" series and on the species described by Regan[3] and Lloyd[4] from Eastern Tibet. He found that

"From the northern area seventeen species of fish are at present known, belonging to the families Siluridae and Cyprinidae. From the southern area thirty-six species of these two families are recorded in the *Fauna of British India*. These two groups have only two species in common (*Schizothorax esocinus* and *Diptychus maculatus*).[5] (These two species are also the only forms from the Trans-Himalayan Indus which have not hitherto been found in the Trans-Himalayan Brahmaputra. Thus there are no species common to the latter and to the rivers of the south face of the Himalayas). Thus of these two families there are fifteen species confined to the northern regions, thirty-four to the southern, and two are found in both."

It may, however, be noted that while Day's conclusions are based on a study of the forms occurring to the north and the south of the western portion of the Himalayas, Stewart's remarks relate to the forms found in the eastern portion of that great range. Both these authorities are, however, in complete agreement that there is no similarity between the

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[1] Stewart, F. H.—Comparison of the fish fauna of the north and the south faces of the great Himalayan range. *Rec. Ind. Mus.*, III, pp. 121-123 (1909).

[2] Day, F.—*Scientific Results of the Second Yarkand Mission.* Ichthyology, pp. 1-25 (Calcutta: 1878).

[3] Regan, C. Tate.—Descriptions of five new Cyprinid fishes from Lhasa, Tibet. *Ann. Mag. Nat. Hist.*, (7) XV, p. 185 (1905); Descriptions of two new Cyprinid fishes from Tibet. *Ibid.* (7), XV, p. 300 (1905).

[4] Lloyd, R. E.—Report on the fish collected in Tibet by Capt. F. H. Stewart, I.M.S., *Rec. Ind. Mus.*, II, pp. 341-346 (1908).

[5] The known distributional records of *Schizothorax esocinus* Heckel and *Diptychus maculatus* Steind show that these species do not occur on the south face of the Himalayas and are typical members of the Central Asiatic fauna.

fish-fauna of the northern and the southern faces of the great Himalayan range. This conclusion appears to be based mainly on the distribution of the Schizothoracinae, and it is, therefore, of interest to examine the two faunas more closely.

FISH OF CENTRAL ASIA AND OF INDIA.

By " Central Asia " I mean the highlands bordered on the north by the Tien Shan Mountains and on the south by the north face of the Himalayas. To the west, where the Himalayan range does not extend, the Hindu Kush range forms the northern boundary while the southern and western boundaries are ill-defined. Towards the east of the headwaters of the Hwang Ho and the Yangtze Kiang form an undefined boundary. Within these limits are included the headwaters of the Jaxartes and the Oxus, the basins of the Hari Rud and the Helmund, the Trans-Himalayan portions of the Indus and the Brahmaputra, the Tarim Basin, the basin of Lake Balkash, the Mongolian Lake Basin and Tsaidam. The fauna of this vast territory, except near the fringes towards the east,[1] and the west,[2] is composed of the Schizothoracinae, of the catfishes of the genus *Glyptosternum* McClelland (Family: Sisoridae) and of the loaches of the genus *Nemachilus* van Hass. (Family: Cobitidae). Of these three types of fishes, the genus *Nemachilus* is the most widely distributed, as it is found not only throughout the Oriental Region, but its range extends to Africa as well. Though this genus is equally abundant in the northern and southern territories of the Himalayas, the species of the two regions are so different from one another that they can be readily distinguished.[3] The Trans-Himalayan species usually grow to a fairly large size; the body is greatly elongated and almost whip-like posteriorly. The skin is totally devoid of scales. The colour on the sides forms a mottled pattern. The species of the Indian region are usually small in size and possess short, stumpy bodies. Small scales, sometimes hidden in the skin, are usually present, while the body is invariably marked by a series of transverse bands. Several attempts have been made to subdivide the fishes of this genus, but from an intensive study of extensive material from the northern and the southern faces of the Himalayas I have not been able to discover any reliable characters for separating the groups recognised as genera by other workers. In spite of the great difference in the appearance of the

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[1] In my account of the " Fish of Afghanistan " (*Journ. Bombay Nat. Hist. Soc.*, XXXVI, pp. 688-706, 1933) I gave a short review of the types of fishes found in Waziristan, Baluchistan, Seistan, Chitral; the Pamirs and the Kashmir and in an addendum some further details are given on the information supplied by Prof. L. S. Berg. It will be seen how, with the exception of Chitral and the Pamirs, the Central Asiatic fauna becomes less marked as we move away from the central zone.

[2] In the lists of Chinese fishes given by Professor Tamezo Mori in his recent work entitled " Studies on the Geographical Distribution of Fresh water Fishes in Eastern Asia " (Chosen: 1936), we find that only one species of *Schizopygopsis* Steindachner is listed from Hoang-Ho, three species of *Schizothorax* Heckel, five species of *Oreinus* McClelland and two species of *Schizopygopsis* from the Yangtze Kiang and two species of *Schizothorax* and three species of *Oreinus* from Southern China. There is a considerable mixture of the Schizothoracine element with the typical Oriental forms in Szechuan, Yunnan and South China.

[3] Hora, S. L.—On Fishes belonging to the family Cobitidae from high altitudes in Central Asia. *Rec. Ind. Mus.*, XXIV, pp. 63-83 (1922).

northern and the southern forms there can be no doubt regarding the genetic affinity of the two types.

The Central Asiatic group of species can be divided ecologically into two categories,[1] (i) those that live in shallow, rapid-running waters and (ii) those that live in lakes. The lake-forms possess a secondarily developed large air-bladder in addition to the original structure enclosed in two bony capsules. The free air-bladder referred to above is, in my opinion, a secondary acquisition developed as an adaptation to life in deeper waters. The form of the free air-bladder is so varied that it is difficult to resist the conclusion that the production of a secondary free air-bladder in certain species of *Nemachilus* has independently occurred again and again in different lakes of Central Asia—the presence of intermediate forms in shallow, sluggish waters lends support to this hypothesis On the southern face of the Himalayas there are no large lakes and even the small ones that exist are probably not of any great antiquity, since they do not possess any endemic faunas. The lakes of northern Burma,[2] however, are of considerable age, as their fish faunas are characterised by several abberant and highly interesting indigenous forms. In this region we get certain species of *Nemachilus* which have developed a secondary air-bladder[3] but their general build is similar to that of the forms found in India. It may be concluded from the above that the Nemachili of the north and the south faces of the Himalayan range, though genetically identical, represent totally different races.

There are only two species of the genus *Glyptosternum*, *G. reticulatum* McClelland and *G. maculatum* (Regan). The latter is known from Eastern Tibet, while the former is widely distributed in the upper reaches of the Indus, the Kabul, the Amu-Darya and the Syr-Darya Rivers. There is reason to believe that the two species have been produced as a result of isolation and segregation of a once widely distributed ancestral stock. A great variety of Glyptosternoid fishes is found in Siam, Yunnan, Burma and the Brahmaputra drainage of India[4]. Recently I[5] have suggested the probable origin of the Glyptosternoid fishes from *Pseudecheneis*-like ancestral forms, but whatever may be the origin of these interesting fishes there can be no doubt that the Trans-Himalayan *Glyptosternum* has its nearest allies in Siam, Yunnan, Burma and north-east India. Here again, though we find a close genetic similarity between the Himalayan and the Trans-Himalayan species, the diversity of form is so pronounced that the two faunas must be regarded as distinct.

The Schizothoracinae are small-scaled Barbels with their nearest allies in the so-called large-scaled or moderate-scaled Barbels of the

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[1] Hora, S. L.—Report on Fishes of the Yale North India Expedition. Part I: Cobitidae. *Mem. Conn. Acad.*, X, pp. 299-305 (1936).

[2] Annandale, N.—Fish and Fisheries of the Inle Lake. *Rec. Ind. Mus.*, XIV, pp. 33-64 (1918); Prashad, B. and Mukerji, D. D. *Rec. Ind. Mus.*, XXXI, pp. 161-223 (1929).

[3] Hora, S. L.—The Value of Field Observations in the Study of Organic Evolution. *Journ. Bombay Nat. Hist. Soc.*, XXXIV, pp. 377, 378, 382 (1930).

[4] The distribution of the Glyptosternoid fishes is as follows: *Oreoglanis* Smith in Siam; *Glaridoglanis* Norman in Yunnan; *Euchiloglanis* Regan in Tonkin, China, Burma and the Brahmaputra drainage of India; *Exostoma* Blyth (used in its broadly accepted sense) in Burma and *Glyptosternum* McClelland in Kashmir, Turkestan and Tibet.

[5] Hora, S. L.—On a New Genus of Chinese Catfishes allied to *Pseudecheneis* Blyth. (In press.)

Oriental and the Aethiopian regions. Both kinds of Barbels occur in diverse types of habitats—from strong currents to muddy pools—and have consequently become differentiated into a variety of closely related genera, which are often very difficult to distinguish from one another. The Schizothoracinae are distinguished from the Cyprininae by the possession of minute scales but in some cases the scales are entirely absent. A membranous sac or slit anterior to the anal fin, which is laterally bounded by a row of vertically placed scales, like eave-tiles, and which are continued along the base of the anal fin, is also characteristic of the Schizothoracinae. On the southern face of the Himalayas, this subfamily is represented by the genus *Oreinus* McClelland which is spread from Afghanistan along the whole Himalayan and contiguous ranges of hills to south-eastern China. So far as is known, these fishes appear to be strictly residents of rivers in the hilly regions, neither descending far into the plains nor occurring in the level plateaux on the summits of the mountains. Their mouth is armed with a special adhesive device which enables them to resist the rapid currents of the torrential streams. Though *Oreinus* is a well recognised morphological genus, there is every reason to believe that it represents only specialised members of the genus *Schizothorax* Heckel.[1] The two genera interbreed very freely and in several large collections intermediate forms between *Schizothorax* and *Oreinus* are not uncommon. Several Himalayan rivers have Trans-Himalayan sources and it is along these channels that *Oreinus*, a representative of the Schizothoracinae, has probably come down during floods, etc., to the Himalayan rivers. No other genus of this subfamily is found in the small torrential streams of the Himalayas. Tchang[2] has recently described two species of *Barbus* Cuvier from Yunnan, *B. regani* and *B. normani* in which the scales are minute and their general build is very much like the Schizothoracinae, except that they do not possess the tiled rows of scales in front of and at the sides of the anal fin. It thus seems likely that such species of *Barbus* were the progenitors of the Schizothoracinae. In the case of the Schizothoracinae, therefore, we have specially modified Oriental Barbels, but the differences between the two types of Barbels are sufficiently well marked for distinguishing the fish faunas of the northern and the southern faces of the Himalayas.

The great variety of other Catfishes and Carps that characterise the aquatic fauna of the southern face of the Himalayas is not at all represented on the northern face of the range.

PHYSICAL FACTORS AND THE CHARACTERISTIC FEATURES OF THE TWO FAUNAS.

In an account of the 'Ecology, Bionomics and Evolution of the Torrential Fauna'[3] it was shown that the physical factors of an environment play a great part in the association of the fauna of a particular

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[1] Hora, S. L.—The Fish of Chitral. *Rec. Ind. Mus.*, XXXVI, pp. 307-310 (1934).

[2] Tchang, T. L.—Two New Species of *Barbus* from Yunnan. *Bull. Fan Mem. Inst. Biology*, (Zool.), VI, pp. 60-63 (1935).

[3] Hora, S. L.—Ecology, Bionomics and Evolution of the Torrential Fauna, with special reference to the organs of attachment. *Phil. Trans. Roy. Soc. London*, (B), CCXVIII, pp. 171-282 (1930).

habitat. Having shown that the fish faunas of the northern and the southern faces of the Himalayan range are almost totally different, though genetically closely related, we may enquire into the factors governing the habitats of the two faunas.

Stewart (*op. cit.*) gave the following four principal physical characteristics of the Central Asiatic region :—(i) its great elevation (usually over 10,000 ft.); (ii) its very low rainfall; (iii) sparse vegetation and (iv) the rapidity of flow of streams. From the point of view of the conditions that govern fish life, the first three factors are of little significance. For instance, the Schizothoracinae are not confined only to high altitudes but are also known from low elevations (for example Seistan, where *Schizothorax* and *Schizocypris* Regan occur, is situated in a deep depression less than 2,000 feet above sea level). It is also immaterial for fish life whether the water in a particular stream is derived from rainfall, glaciers or from springs, as fishes become gradually acclimatised to changes in temperature. Most of the hill-stream fishes feed on insect larvae or aquatic vegetation (mostly slimy algae adhering to rocks and stones), and it is no consequence whether the terrestrial vegetation of the area is sparse or thick. The nature of the river bed and the swiftness of the current are, however, important factors.

It is a general characteristic of the highlands of Central Asia that the rivers run with some rapidity in broad beds of boulders and often expand into marshes and lakelets. Further there are lakes of considerable magnitude dotted all over this area. For an understanding of the correlation between the type of habitat and the corresponding fauna reference may be made to my account of the fish of Chitral cited above. On the southern face of the Himalayas the streams are small and precipitous and there are no large lakes. The nature of the streams is so torrential that very few species of fish are found above an altitude of about 4,000 ft.; the greatly diversified fish-fauna of this region is mainly restricted to valleys. On the southern face of the Himalayas, therefore, fishes require mechanical devices to enable them to withstand the rapidity of the currents, such forms are *Garra* Hamilton, *Glyptothorax* Blyth, *Pseudecheneis* Blyth, etc., which do not grow to a large size, while some, like *Balitora* Gray, are greatly flattened. In the large rivers and lakes of the highlands of Central Asia the conditions of life are presumably not so rigorous and in consequence the rivers are stated by every observer to be teeming with fish life. The fish grow to a fairly large size and are trout-like in appearance, with the exception of *Glyptosternum* which is flattened and is found clinging to rocks, etc.

The most striking feature of the fishes of Central Asia, however, is the degenerate nature of their scales,[1] culminating in their total absence in some forms. As in the Salmonidae, the smallness of the scales in the Schizothoracinae is probably due to the necessity for a supple integument whether in fast-swimming fishes or in those that live in smooth, rapid-running waters, for it must be remembered that whether a fish moves through water swiftly or the water glides over it with great rapidity the physical factors involved are the same in both

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[1] Annandale, N. and Hora, S. L.—The Fish of Seistan. *Rec. Ind. Mus.*, XVIII, p. 154 (1920).

cases. A remarkable feature of the Schizothoracinae is the anal sheath of scales. Besides these enlarged scales, there are usually somewhat larger scales in the scapular region, at the bases of the dorsal and ventral fins and along the lateral line. As the fish moves through the water, these are precisely the regions where, owing to protection afforded by the conical head, fins, and the stream-lined body of the fish, the tearing-away action of the current is least felt. In consequence, these scales do not undergo degeneration to the same extent as on the parts of the body more exposed to the currents. It seems logical, therefore, to assume that the whole of the fish-fauna of the highlands of Central Asia has been modelled to suit the peculiar conditions of the rivers of that region. *Schizothorax*, the perfectly scaled member of the Schizothoracinae, is found in lakes and in large rivers with backwaters,[1] while other genera of the subfamily with scales in varying degree of reduction live in swift waters of varying rapidity.

Along the southern face of the Himalayan range, on the other hand, though the streams are more torrential, we have forms with larger scales. In fact, the *Barbus tor* group, constituting the renowned 'Mahseers' of India, is well represented in the Himalayas and even in *Garra*, which possesses a true vacuum sucker, the body is provided with moderately large scales. The same is true of such mountain genera as *Balitora*, *Psilorhynchus* McClelland, *Crossochilus* van Hass., etc. Even the Siluroids, which live on the exposed surfaces of rocks, such as *Sisor* Hamilton, *Glyptothorax*, *Laguvia* Hora, *Erethistes* Müll. & Trosch., etc., have developed wart-like, hard projections on the skin. This may seem contradictory to what has been stated above regarding the reduction of scales in Central Asiatic fishes, but in reality it is not so. In dealing with the physics of the mechanism of attachment in hill-stream animals it was shown[2] that though at certain velocities the resistance of a body subjected to a current is greatly reduced by the rounding-off of its contours, at other velocities, in some bodies, such as spheres and cylinders, the resistance is actually reduced by the roughening of the surface. Those who have visited the Trans-Himalayan and the Cis-Himalayan areas of the great range will bear out very fully that the nature of the flow of water currents in the two areas differs very considerably. It is these differences in the nature of the currents that account for the different types of fish-fauna of the two regions.

ORIGIN OF THE TWO FAUNAS.

According to Day (*vide supra*, p. 241) at some very early age the Himalayas acted as a barrier between the northern and the southern forms and the resulting isolation kept the two faunas very distinct. This is true so far as it goes and certainly at the present day the Himalayan range is an effective barrier that does not permit the northern and the southern fish-faunas to intermingle. It has been shown above that

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[1] Hora, S. L. and Mukerji, D. D.—Pisces in *Visser's Karakorum*, I, pp. 427, 428 (Leiden: 1935).

[2] Hora, S. L.—Ecology, Bionomics and Evolution of the Torrential Fauna, with special reference to the organs of attachment. *Phil. Trans. Roy. Soc. London* (B), CCXVIII, pp. 254-256 (1930).

the Central Asiatic *Glyptosternum* and *Schizothorax* have their close allies in Yunnan and the adjoining territories of south-eastern Asia. It seems reasonable, therefore, to infer that the fish-fauna of Central Asia was derived from an eastern stock, as I[1] have suggested in regard to the origin of the fish-fauna of India as a whole. The close genetic similarity between the two faunas is undoubtedly due to their common origin, and the dissimilarity between them is probably due to their differentiation in different geological ages, long isolation and the resulting segregation. Attention may here be directed to Regan's[2] hypothesis "that as a rule the first step in the origin of a new species is the formation of a community with a new and restricted environment, or with new habits; in other words, that some form of isolation, either localization or habitudinal segregation, is the condition of the development of a new species." What is true of the species is also applicable to faunas as a whole. The fish-fauna of Central Asia, at any rate, affords a remarkable instance in support of this hypothesis.

To compare the origin of the Trans-Himalayan and the Cis-Himalayan fish-faunas it seems worth while to give a very brief account of the geological history of the Himalaya, but unfortunately our knowledge of Trans-Himalayan geology is very meagre indeed.

"There is no evidence to show that the Himalaya, as a great mountain range, are older than the latter part of the Eocene period".[3] Before that the Himalayan area formed the northern coast of Gondwanaland and a number of rivers flowed northward into the Tethys Sea of that period. The orogenic movement, which was strongly pronounced during the Oligocene, probably began in late Cretaceous times and continued throughout the Eocene and Middle Tertiary periods. There is considerable evidence to show that it was still active during the Pliocene and the later periods. The ossiferous beds of Ngari Khorsum and of the Karewas of Kashmir, however, indicate that during the Pleistocene period the Himalayas had already acquired the general features of their present-day form. The nature of the Siwalik deposits shows that the main drainage lines on the south face of the Himalayas date as far back as the Pliocene epoch and that "the rivers which brought down the sands and boulders from the mountains to build up the Siwaliks of the Duns and the Hundes were the direct ancestors of our modern Sutlej and Ganges."

From the generalised nature of the Trans-Himalayan fish-fauna it may be surmised that the eastern portion of the Tibetan plateau was the first area to be lifted and raised above the neighbouring Chinese territory. The drainage of this new land joined the then existing drainage of southern China and thus channels were established for the Chinese forms to colonise new lands. As the crustal movements gradually lifted the Tibetan region, better adapted hill-stream forms

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[1] Hora, S. L.—Geographical Distribution of Indian Freshwater Fishes and its bearing on the Probable Land Connections between India and the Adjacent Countries. *Curr. Sci.*, V, pp. 351-356 (1937).

[2] Regan, C. Tate.—Mendelism and Evolution. *Nature*, CXIII, p. 569 (1924).

[3] For geographical and geological facts about the history of the Himalayas I am indebted to Burrard and Hayden's "A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet" revised by Burrard and Heron (Delhi: 1933).

were able to invade the higher reaches of these streams. The association of the fish-fauna shows that these rivers had fairly broad valleys with deep beds of boulder and rapid-running currents. It has then to be presumed that at a certain period a localised disturbance caused this region to be lifted up so as to isolate the fauna of this area from the ancestral stock. The geographical distribution of the Schizothoracinae shows that the waters of Central Asia may have flowed at first towards the east, then towards the west and north before the present drainage pattern was established.

"On the basis of his geomorphological studies, Dr. de Terra has reconstructed the Tertiary drainage pattern of the western part of the Tibetan plateau. A number of rivers ran from west to east, one of them occupying the present valley of the Upper Indus. It is difficult to resist the conclusion that a similar pattern extended farther north, the Tarim basin draining into the Hwang-ho."[1] According to Burrard, Hayden and Heron[2], the evidence furnished by the feeders of the Trans-Himalayan Brahmaputra shows that the Tsangpo formerly flowed through Tibet from east to west, and that of the great rivers of the world, "the Brahmaputra furnishes the only instance of drainage flowing in a diametrically opposite direction to what it formerly did, though still occupying the same bed."

The Schizothoracinae are at present found in at least twelve major river systems and numerous closed basins adjoining the plateau of Central Asia. *Glyptosternum* is also found in the eastward and westward flowing rivers. Mukerji and I[3] found the same species of *Nemachilus* in the headwaters of the Indus and the Karakash rivers. These facts concerning the geographical distribution of Central Asiatic fishes can only be explained reasonably on the assumption that after the establishment of the typical highland fish fauna local upheavals repeatedly led to changes in the drainage pattern of this region and thus made possible the wide dispersal of these forms.

So in the origin and distribution of the fish-fauna of Central Asia, the first step was the colonisation of the newly produced lands of Eastern Tibet, probably during the post-Eocene period, by the fauna of southern China, particularly of Yunnan. The second step was the lifting of this region, which resulted in the isolation of the fauna of the upper reaches by the reversal of the drainage system, and finally through localised orogenic movements in the region of the Tibetan trough the drainage pattern was made to oscillate from time to time resulting in the wide dispersal of the Central Asiatic forms within the limits of the trough defined above.

As indicated above, the fish of the southern face of the Himalayas are highly specialised and appear to have spread over this region from the east at a somewhat later date, possibly in the late Miocene or Pliocene periods. Of the hill-stream fishes of this region we have fossil records of *Bagarius* Bleeker, a widely distributed genus of the somewhat larger

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[1] Hutchinson, G. E.—Yale North India Expedition. *Nature*, CXXXIV, p. 87 (1934).

[2] Burrard, S. G. and Hayden, H. H.—*A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet.* 2nd Edition, revised by Burrard, S. G. and Heron, A. M. (Delhi: 1933).

[3] Hora, S. L. and Mukerji, D. D.—Pisces in *Visser's Karakorum* I, pp. 427-428 (1935).

rivers of India, Burma and the Malay Archipelago, from the Siwalik formations of Nahan and the Tertiary formations of Padang in Sumatra. All students of Oriental fishes are familiar with the great similarity between the south Himalayan fish fauna and that of Burma, Siam, the Malay Peninsula and the Archipelago and Indo-China. In another place I[1] discussed the probable origin of the fish fauna of India and showed that it was derived from the eastern countries. For the probable mode of dispersal of fishes from east to west reference may be made to Gregory[2] and Gregory and Gregory[3] who have attempted to demonstrate that in south-eastern Asia the western rivers beheaded the rivers on the east; thus effecting the transference of eastern fauna towards the west. As the total Himalayan uplift was accomplished in three or more stages, every wave of orogenic movement may have affected the drainage pattern of that period, but, as evidenced by the distribution of freshwater fishes, it seems that every time the western rivers captured the waters of the eastern rivers. Changes in the drainage of the southern face of the Himalayas may also have resulted from localised disturbances. At any rate, it seems certain that when the South Chinese fauna began to spread along the southern face of the Himalayas, even the parental stock in China had probably already undergone considerable changes due to the torrential nature of the streams on the newly produced precipitous hill-sides.

It is thus seen that though the fauna of the northern and the southern faces of the Himalayas is derived from the same source, the Central Asiatic fauna, comprising comparatively less specialised forms, was probably differentiated at an earlier date when the parental stock was of a generalised nature; while that of the southern face of the Himalayas, comprising highly specialised forms, was produced at a later date when the original stock had already become fairly well adapted for life in torrential streams.

SUMMARY.

Attention is directed to the conclusions reached by Day and Stewart as a result of the comparison of the fauna on the northern and southern faces of the Himalayan range. From a critical examination of the fish of Central Asia and of India evidence is adduced in support of the earlier conclusions that the two fish faunas are very distinct from each other. The physical factors governing fish life in Central Asia and on the southern face of the Himalayas are discussed and it is shown that the fish of the two regions are adapted to suit the nature of their respective streams. The characteristic features of the two fish faunas are examined and their close correlation to environmental factors is indicated. The probable origin of the two faunas is described and it is shown that though the

[1] Hora, S. L.—Geographical Distribution of Indian Freshwater Fishes and its bearing on the Probable Land Connections between India and the Adjacent Countries. *Curr. Sci.*, V, pp. 351-356 (1937).

[2] Gregory, J. W.—The Evolution of the River System of South-Eastern Asia. *Scottish Geog. Mag.*, XLI, pp. 129-141 (1925).

[3] Gregory, J. W. and Gregory C. J.—The Alps of Chinese Tibet and their Geographical Relations. *Geog. Journ.*, LXI, pp. 153-179 (1923).

Central Asiatic and the Indian faunas are derived from the same source in south-eastern Asia, especially Yunnan, the former probably became differentiated at an earlier age when the parental stock was of a generalised nature, whereas the fauna of the southern face of the Himalayas was derived from a younger and more vigorous stock which had already become specialised in south-eastern Asia for life in torrential streams.

DISTRIBUTION OF HIMALAYAN FISHES AND ITS BEARING ON CERTAIN PALAEOGEOGRAPHICAL PROBLEMS.

By SUNDER LAL HORA, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta.*

The physical and biological factors that govern the life of a torrential fauna[1] are of a very special nature and tend to restrict the distribution of hill-stream animals. Of the various physical factors, two are of special significance, the rapidity of the current and the consequent high percentage of dissolved air in mountain brooks. In response to the former, the organisms have developed various types of adhesive devices to prevent being washed away by the strong currents and spend most of their life clinging to rocks and boulders, while the greatly flattened or torpedo-shaped body presents a stream-lined form to the rushing current. As an adaptation to the high percentage of oxygen in these waters, the respiratory organs are reduced, for in such habitats even a comparatively much smaller area is sufficient to absorb enough oxygen for the requirements of an organism. Hill-stream animals are, as a rule, not suited for existence in muddy, sluggish water, and under such conditions usually die through asphyxiation within a very short period. As an example of biological factors, attention may be directed to the fact that the majority of the hill-stream fishes feed by scraping off algal slime and insect larvae that encrust rocks and stones, and consequently their mouths and jaws are specially modified for this purpose. It is obvious that the same method of feeding cannot be employed on a muddy substratum.

The distribution of the highly specialised hill-stream fishes, therefore, cannot be affected by the ordinary methods of dispersal along water channels, because the nature of the substratum[2] and the rapidity of the current are very potent factors for the existence of these animals. Their distribution along a mountain range has to be explained in terms of river-captures, longitudinal river valleys or tilting of mountain blocks so that the courses of the streams may alter without impairing their torrential nature. The distribution of the southern Himalayan fishes shows that all the three processes have been responsible in varying degrees for the dispersal of the fish fauna in this region, and that the Himalayan uplifting movement, though it may have been fairly uniform in the beginning over large areas, certainly became localised towards the end. Through the influence of these unequal orogenic movements, extending from the middle Eocene to almost within, geologically speaking, recent times, the Himalayas became hydrographically divided into a number of units which can be roughly demarcated with the help of their fish faunas. It is the object of this article to elucidate the probable

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[1] Hora, S. L.—Ecology, Bionomics and Evolution of the Torrential Fauna, with special reference to the organs of attachment. *Phil. Trans. Roy. Soc. London*, B, CCXVIII, pp. 171-282 (1930).

[2] Hora, S. L.—Nature of Substratum as an important factor in the ecology of Torrential Fauna. *Proc. Nat. Inst. Sci. India*, II, pp. 45-47 (1936).

boundaries of these hydrographical divisions of the Himalayas. Evidence is also adduced from the nature of the fish faunas of the north and south faces of the Himalayas to discuss whether the present-day drainage of the Himalayas is evolved from an ordinary " consequent drainage ", *i.e.*, the rivers flowed north or south of the crest, or is the result of an " antecedent drainage ". Observations are also made regarding the existence of the so-called " Indobrahm " or the " Siwalik River " of the Tertiary period.

DISTRIBUTION OF FISHES ALONG THE SOUTHERN FACE OF THE HIMALAYAS.

Ecologically, the Himalayan fishes can be divided into several categories and in discussing their geographical distribution it is well to bear in mind their respective associations. For instance, several species of *Barbus* Cuvier and *Labeo* Cuvier occur all along the Himalayas, but essentially they are forms of the plains which live in pools or deeper portions of the streams of the Himalayan foot-hills; some of them maintain themselves in swift currents through sheer muscular efforts. *Oreinus* McClelland, on the other hand, represents the Central Asiatic element on the southern face of the Himalayas; it spreads from Afghanistan, along the whole of the Himalayas and the contiguous ranges of hills, to south-eastern China. So far as is known, the fishes of this genus appear to be strictly residents of rivers in hilly regions, neither descending far into the plains nor occurring on level plateaux on the summits of mountains. Unlike the other Schizothoracinae, their mouths are provided with an adhesive device which enables them to resist being washed away in mountain torrents. *Oreinus* is a trout-like muscular fish and seems to have evolved from stocks of *Schizothorax* Heckel that may have been washed down from the Trans-Himalayan sections of some of our modern rivers.

A group of genera,[1] comprising *Crossochilus* van Hass., *Semiplotus* Bleeker, *Chaca* Gray, *Sisor* Hamilton, *Leiocassis* Bleeker, *Gagata* Bleeker, *Nangra* Day, *Bagarius* Bleeker, etc., is found in the streams of the foot-hills in comparatively deeper and less rapid-flowing waters; while Loaches or Loach-like cat-fishes, such as *Nemachilus* van Hass., *Lepidocephalichthys* Bleeker, *Acanthophthalmus* van Hass., *Somileptes* Swainson, *Acanthopsis* van Hass., *Olyra* McClelland, *Amblyceps* Blyth, *Erethistes* Müll. and Trosch., *Parasilurus* Bleeker, etc., live among pebbles and stones at the bottom and escape the effect of the rushing current. Though *Garra* Hamilton and *Glyptothorax* Blyth are provided with adhesive devices they are found both in torrential streams and in streams with moderate currents. These are essentially rapid-water forms, but have taken secondarily to slow waters. The typical torrential genera are *Pseudecheneis* Blyth, *Exostoma* Blyth, *Euchiloglanis* Regan, *Balitora* Gray and certain species of *Psilorhynchus* McClelland; these are res-

[1] Attention may also be directed to the amphibious, marsh-loving fishes of the genus *Ophicephalus* which are sometimes found at the sides of mountain streams in burrows and are not affected by the strength of the current. These are found throughout the plains of south-eastern Asia and are capable of wriggling about on wet ground.

tricted in their distribution to very fast flowing waters, and are accordingly the most highly adapted forms for life in mountain brooks.

Before discussing the distribution of the genera enumerated above, it seems worth while to form some conception of the age and geographical divisions of the Himalayas. According to Burrard, Hayden and Heron (p. 86)[1],

"Though the whole length of the great Himālaya range belongs to one geological age, yet the Punjab Himālaya are supposed to have arisen at a somewhat later date than the Nepāl Himālaya. The presence at elevations of 16,000 feet in the Punjab Himālaya of nummulites indicates that this portion of the range did not emerge from the sea till comparatively recently."

It is further stated that

"The rocks of the Siwalik range are stratified and date from the later half of the Tertiary period; those of the outer Himālaya are stratified also but are very much older."

For descriptive purposes the total length of the Himalayas from Namcha Barwa in the east to Nanga Parbat on the west, about 1,500 miles, is divided into four sections by three meridional lines, (i) The Tista, (ii) The Kali and (iii) The Sutlej. The easternmost section, about 450 miles, is known as the Assam Himalayas, the next section of about 500 miles is the Nepal Himalayas, then a length of about 200 miles is the Kumaon Himalayas and the last about 350 miles form the Punjab Himalayas.

"Whilst in all the four parts the great range rises like a wall and the outer ranges tend to run parallel to it, no one portion of the Himālaya resembles another."

"In Nepāl we find numerous rivers cutting across the Great Himālaya range; in the Punjab between the Sutlej and the Indus we do not find one. In Népal the great peaks stand in clusters and rows; the great peak of the Punjab stands in solitude."

In considering the distribution of fishes along the south face of the Himalayas, there is one fact which appears most striking at the very outset, *i.e.*, the great variety of forms towards the east as compared with the case of the west. For instance, in the Brahmaputra and the Tista drainage systems all the genera of fishes enumerated above are found; while towards the west in the Gangetic drainage system we only find *Chaca*, *Amblyceps*, *Bagarius*, *Glyptothorax*, *Erethistes*, *Gagata*, *Nangra*, *Lepidocephalichthys*, *Nemachilus*, *Garra* and *Semiplotus*. Not one of these genera represents a highly specialised torrential form, and, with the exception of *Gagata*, *Nangra* and *Semiplotus*, all are widely distributed in the Oriental Region; the range of *Nemachilus*, *Garra* and *Glyptothorax* extends for a considerable distance towards the west. There is one genus of large Catfishes—*Sisor* Hamilton—which was recorded by Day from both the Indus and the Ganges systems; but it was found by Shaw and Shebbeare and Mukerji to occur also in the Tista river. In the Punjab Himalayas or the Indus drainage system *Chaca*, *Erethistes* and *Semiplotus* are absent. Unfortunately no systematic account of the Himalayan fishes has so far been published, and in the case of old records precise localities are not mentioned. In the case of *Semiplotus*, however, it may be noted that Day gave its distribution as "Assam, and Chittagong Hill ranges, as well as Burma", but recently

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[1] Burrard, S. G. and Hayden, H. H.—*A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet.* 2nd Edition, revised by Burrard, S. G. and Heron, A. M. (Delhi: 1933).

I[1] recorded *S. semiplotus* (McClelland) from the portion of the Nepal Himalayas drained by the Gandak. Though our present-day knowledge of the distribution of the Himalayan fishes is very imperfect, it is doubtful whether the special forms of the Assam Himalayas, such as *Balitora*, *Psilorhynchus*, *Parasilurus*, *Olyra*, *Pseudecheneis*, etc., will ever be found in the western Himalayas. These very genera or some other closely allied forms are found in Burma, Southern China, Siam, the Malay Peninsula and the Archipelago and Indo-China on the one hand and in the hills of Peninsular India on the other. It seems remarkable that the distribution of these eastern forms, instead of being continued along the Himalayas, is deflected from the limits of the Tista drainage towards the south. This most striking feature in the distribution of Indian fishes is explained later (*vide infra*, p. 255).

The records of distribution of the Himalayan fishes, as given above, support the hypothesis that I[2] have suggested elsewhere regarding the eastern origin of the freshwater fish fauna of India. The above series of genera represents various phases of migration of the fauna. For instance, in the case of such widely distributed genera as *Barbus*, *Labeo*, *Garra*, *Nemachilus*, *Lepidocephalichthys*, *Bagarius*, *Amblyceps*, etc., one has to imagine a large, deep river in low hills fed by small, broad, rocky tributaries. The wide distribution of these genera along the entire length of the Himalayan foot-hills shows further that such a river must have had a longitudinal course, like that of the Trans-Himalayan sections of the Brahmaputra and the Indus. It was, no doubt, during this type of drainage of the Himalayas that the large river fishes of India, such as *Catla* (represented in Siam and Indo-China by *Carpiocatla* Boulenger), *Cirrhina*, large-scaled Barbels, *Wallago* Bleeker, *Silonia* Swainson (replaced in Siam and Indo-China by *Pangasianodon* Chevey), *Pangasius pangasius* (Ham.), etc., could spread almost all over India. The presence in the Ganges, Brahmaputra and Indus of identical species of freshwater dolphins and turtles also shows the course and nature of this mighty river. Thus the distribution of the freshwater fish fauna of northern India lends a strong support to the existence of a river of the type of the Indobrahm, envisaged by Pascoe[3] and Pilgrim[4]. From the geological evidence it is concluded by these authors that such a river existed even in the Eocene period. Its lower course is evident from the distribution of the boulder conglomerates, but the position of its headwaters is a matter of mere conjecture. It is stated that the headwaters of the Indobrahm consisted of the Assam portion of the present-day Brahmaputra. Dr. C. S. Fox of the Geological Survey of India has pointed out to me in a note that this cannot be the case as

"A marine gulf in Burma and Upper Assam in Cretaceous times became an estuary in the Eocene and the mouth of a very important river in the Miocene. I do not see how

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[1] Hora, S. L.—Notes on Fishes in the Indian Museum, XXIX. On a Collection of Fish from Nepal. *Rec. Ind. Mus.*, XXIX, pp. 45, 46 (1937).

[2] Hora, S. L.—Geographical Distribution of Indian Freshwater Fishes and its bearing on the probable land connections between India and the adjacent countries. *Curr. Sci.*, V, pp. 351-356 (1937).

[3] Pascoe, E. H.—Early History of the Indus, Brahmaputra and Ganges. *Quart. Journ. Geol. Soc.*, LXXV, p. 136 (1919).

[4] Pilgrim, G. E.—Suggestions Concerning the History of the Drainage of Northern India. *Journ. As. Soc. Bengal* (N. S.), XV, p. 81 (1919).

the debouchure of a river into a delta can become the source of a river that is to go to sea all the way round the Himalayan foothills to the Indus."

In the same note he stated that

> "It is probable that as the old geosyncline of the Himalayan belt was folded up into a mountain chain a depression was established parallel to it to the south. In the swampy country the rivers from the rising hills discharged, and their silt was spread out laterally into great alluvial fans. It is these Siwalik deposits of freshwater fluviatile deposition that have been joined up lengthways, along the axis of the depression, and thus have supplied material for the belief in a Siwalik river."

This view is, however, disputed by Wadia[1] who has drawn attention to the remarkable homogeneity and uniformity of the Siwalik deposits all along this strike, from Assam to the Punjab. This strike continuity is inconsistent with the fan theory of deposition at the mouths of isolated transverse streams and is best explained by deposition in a continuous longitudinal basin of a wide east-west flowing river.

Without going into the geological merits of the case, it seems clear that the distribution of freshwater fishes, as indicated above, postulates the existence of a mighty river of the nature of the Indobrahm.[2] This river at an early stage of its existence certainly did not have its head-waters in the Assam portion of the present-day Brahmaputra, but it must have crossed the broad isthmus that joined India with the main Asiatic continent and had its headwaters further east. The distribution of the large freshwater river fishes of the Oriental Region (*vide supra*, p. 254) can only be explained on this assumption. Even the occurrence of precisely the same river fishes, especially of the giant forms as *Catla catla* (Ham.), *Labeo rohita* (Ham.), *Cirrhina mrigala* (Ham.), *Wallago attu* (Bloch), *Pangasias pangasias* (Ham.), *Silonia silondia* (Ham.), and others in Burma, Assam, Bengal, the United Provinces, the Central Provinces, Orissa and the Punjab postulates the existence of a large, longitudinal river and its subsequent divisions into several independent watersheds. As the Himalayas rose to a great height in the region of this isthmus (mostly the western part of the Assam Himalayas and eastern part of the Nepal Himalayas) all the evidence concerning the north-eastward extension of the Indobrahm seems to have been obliterated. The uplift movement was probably most active in this region as we find practically all the highest peaks of the Himalayas clustered round this area. This differential movement, which probably occurred late in the Miocene period, must have obliterated all traces of the eastward extension of the Indobrahm and also acted as a barrier between the eastern and the western Himalayan fishes. The new stocks of specialised hill-stream fishes from the east, not finding means to cross this barrier, were deflected towards south-west along the Satpura Trend which probably at this period stretched across India as a pronounced

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[1] Wadia, D. N.—The Tertiary Geosyncline of North-West Punjab and the History of Quaternary Earth-movements and Drainage of the Gangetic Trough. *Q. J. Geol. Min. Met. Soc. India*, IV, pp. 69-96 (1932).

[2] Evidence of the existence of the Indobrahm is also furnished by "the tendency of the tributaries of the supposed Indobrahm to flow in a direction opposite to that of the modern trunk river. If but one feeder has been observed to take a course contrary to that of the main stream, it might have been attributed to some local accident of topography, but when all the principal affluents of a long section of the river do so, it is indicated that the Indobrahm flowed from east to west, when the tributaries were developed, and that its direction of flow has been reversed." (Burrard, Hayden and Heron, *op. cit.*, p. 349.)

range from Gujarat to the Assam Himalayas. From Gujarat the hill-stream fauna migrated towards the south along the Western Ghats and spread to the hills of the Peninsula in the extreme south. It may here be noted that the Indobrahm fauna of moderate, deep currents does not extend to the south below the Kistna river, while the torrential fauna of the Eastern Himalayas is represented in the hills of the extreme south of the Peninsula by forms such as *Silurus* Linn., *Bhavania* Hora, *Parapsilorhynchus* Hora, *Thynnichthys* Bleeker, etc.; it is not found in Ceylon, for the island had by then become separated from the mainland. Further, it has no representative in Africa, because the main land bridge between Peninsular India and Africa had already disappeared during the Eocene period, though a mass of land in the region of the Gulf of Oman probably existed till Pliocene or possibly even Pleistocene times.[1] This course of events, in my opinion, explains the anomalous distribution of the various hill-stream fishes of India, and suggests a reason for the closer similarity of the South Indian fish fauna with that of the Malay Peninsula and the Archipelago.

To the west of this supposed barrier in the Eastern Himalayas the hill-stream fauna is composed of ordinary rapid water fishes; most of the genera are more or less uniformly distributed all along the range. In the Nepal Himalayas, however, the eastern element, *Semiplotus*, *Chaca* and *Erethistes*, is more pronounced. The last two genera extend up the Ganges system and are absent from the Punjab Himalayas. The Punjab Himalayas, being furthest from the source of distribution, has the least number of hill-stream forms in its fauna. It may, therefore, be presumed that at the end of the Kumaon Himalayas or somewhere in that region there is probably another barrier, which isolated the fauna of the Punjab at a fairly early age. This conclusion is justified by the detailed studies recently carried out by Mukerji[2] and Hora[3] on the specific position of some of the Himalayan fishes. The isolation of the Punjab Himalayan forms may have resulted through the differential earth-movements which elevated the Potwar basin into a plateau and led to further dismemberment of the Indobrahm into the Indus and the Ganges systems of the present-day drainage of the Himalayas. In any case, this barrier must have been formed at a later date and is not contemporaneous with the Eastern Himalayan barrier. This presumption is based on the fact that after the formation of the Eastern Himalayan barrier there was for some time no river of the nature of the Ganges flowing into the Bay of Bengal to divide the Peninsula from the Extra-Peninsula: such a river, if it had existed, would in itself have acted as a barrier and have inhibited the dispersal of Himalayan fishes to the hills of the Peninsula. It is thus seen that the Indobrahm must have continued to flow towards the Arabian Sea even after the severence of its

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[1] Wiseman, J. D. H. and Sewell, R. B. S.—The floor of the Arabian Sea. *Geol. Mag.*, LXXIV, pp. 219-230 (1937).

[2] Mukerji, D. D.—Report on Burmese Fishes collected by Lt.-Col. R. W. Burton from the tributary streams of the Mali Hka river of the Myitkyina District (Upper Burma). *Journ. Bombay Nat. Hist. Soc.*, XXXVII, pp. 49-59 (1934).

[3] Hora, S. L.—On a further Collection of Fish from the Naga Hills. *Rec. Ind. Mus.*, XXXVIII, pp. 320-324 (1936).

connection with the Far East; its dismemberment seems to have occurred in several stages. After the formation of the Eastern Himalayan barrier its headwaters may have been in the Nepal Himalayas. A later upheaval probably divided it into a westerly flowing Indus and an easterly flowing Ganges. The formation of this drainage pattern has a counterpart on the northern face of the Himalayas also, namely, the reversal of the direction of flow of the Tsangpo towards the east and the westerly flowing Indus.

From the distribution of the fish fauna along the southern face of the Himalayas it is thus possible to recognise three well marked divisions—the Eastern Section up to and including the drainage basin of the Tista river, the Middle Section up to the Sutlej river and then the Western Section comprising the entire drainage basin of the Indus. The precise boundaries of these sections can only be demarcated when our knowledge of the various Himalayan species and their races becomes more exact. It may be indicated that the Jumna river was a tributary of the Sutlej not very long ago, though it now joins the Ganges. The oscillation of the Jumna makes it still more difficult to define the various sections without a proper survey of the fish fauna of the Himalayas.

HIMALAYAN FISHES AND THEIR BEARING ON THE EVOLUTION OF THE PRESENT-DAY DRAINAGE SYSTEM OF THE HIMALAYAS.

With the exception of *Oreinus* and *Nemachilus*, none of the genera enumerated above are found on the northern face of the Himalayas, the fish fauna of which comprises the Schizothoracinae, *Glyptosternum* McClelland and *Nemachilus*. In another place I[1] have shown that the Nemachili of the northern and the southern faces of the Himalayas are very distinct from each other and that *Glyptosternum* is very different from the other Glyptosternoid fishes found in Siam, S. China, Burma and the Eastern Himalayas. *Oreinus* is a mountain form of *Schizothorax* Heckel and is only found along the slopes of the Central Asiatic plateau, but not on the tableland. In fact, it may definitely be stated that there is no similarity between the fish faunas of the northern and the southern faces of the Himalayas. To account for this I have suggested that the two faunas were probably evolved from the same stock at different geological ages and owing to the barrier provided by the rising Himalayas had little chance to intermingle. The deep gorges and rapids in the course of certain Himalayan rivers with trans-Himalayan courses still isolate the two fish faunas from each other.

With regard to the evolution of the present-day Himalayan drainage pattern two alternative theories have been advanced.

"One of the theories postulates that at an early age the Himalaya had ordinary consequent drainage, the rivers flowing north and south from the crest. This simple drainage pattern is considered to have been modified to its present form by some of the south-flowing rivers cutting back through the range and capturing rivers on the Tibetan side. The much greater precipitation on the south side of the range and the much steeper fall and therefore greater erosive power are put forward as possible reasons for the unusual behaviour of the south-flowing rivers. The alternative theory postulates that the Arun and similar rivers always had their present courses which, when they were inaugurated, were the easiest routes down an irregular surface sloping towards the

[1] Hora, S. L.—Comparison of the Fish-Fauna of the northern and the southern faces of the great Himalayán range. *Rec. Ind. Mus.*, XXXIX, pp. 241-250 (1937).

Gangetic plain. Subsequently the Himalayan range is considered to have risen up across the rivers, but so slowly that by vigorous erosion they were able to keep open their original channels."[1]

The distinctness of the northern and the southern fish faunas of the Himalayas definitely favours the former view. If the rise of the Himalayas had been so slow as to enable the rivers to keep open their channels by vigorous erosion there should have been little or no difference in the fish faunas of the cis- and trans-Himalayan portions of such rivers as the Brahmaputra, the Arun, the Sutlej, the Indus, etc. On the other hand, there is every reason to believe that the rise of the Himalayas was in sharp orogenic movements so that the fishes of the southern face of the range were unable to adapt themselves to very turbulent waters and have, even to this day, remained confined to low valleys and are rarely found above an elevation of four to five thousand feet. In this connection it may also be remembered that the so-called Indian monsoon conditions—south-west for four months and north-east for three or four months—had begun before the Himalayas started to rise, as in the late Cretaceous period open seas of great extent existed to the south of India and some land had been formed to the north. The rise of the Himalayas had a great influence on the distribution of rainfall, for most of the moisture is now precipitated on its southern face; and there is practically no rainfall on the northern face of the Himalayas. Consequently, the rivers along the southern face are very turbulent while those on the northern face are placid, broad-valleyed and deep. Very different sets of ecological conditions were thus produced on the northern and southern faces of the Himalayas and these became accentuated as the mountains rose higher and higher.

When the south-flowing rivers, through erosion captured the rivers on the Tibetan side it was natural that some of the fishes on the Tibetan side should have been washed down on the southern side, but they had to pass through such precipitous channels before reaching congenial conditions that with the exception of one genus of the Schizothoracinae—*Oreinus*, a specialised member of the subfamily fully adapted for life in rapid, mountain streams—no other member of the Central Asiatic fauna has been able to colonise the southern slopes of the Himalayas.

The migration of torrential fishes along the southern face of the Himalayas and from the Eastern Himalayas to the hills of the Peninsula shows that the process of river-capture was a fairly common phenomenon in this territory and also in the region of the contiguous hill-ranges to the east. The distribution of specialised hill-stream fishes strongly suggests that in south-eastern Asia, as a rule, the rivers on the west beheaded the rivers on the east[2] and thus effected the transference of the fish fauna from the east to the west.

SUMMARY.

The physical and biological factors that govern the life of a torrential fauna are examined and it is indicated that the distribution of highly

[1] Wager, L. R.—The Arun River Drainage Pattern and the rise of the Himalayas. *Geog. Journ.*, LXXXIX, pp. 239-250 (1937).

[2] Gregory, J. W.—The Evolution of the River System of South-Eastern Asia. *Scottish Geog. Mag.*, XLI, pp. 129-141 (1925).

specialised hill-stream fishes cannot be effected by the ordinary methods of dispersal ; it has to be explained in terms of longitudinal valleys, river-captures and tilting of mountain blocks.

The distribution of the fish-genera along the southern face of the Himalayas is discussed in terms of the ecological associations of the different types, and it is indicated that at a very early period of the rise of the Himalayas a mighty longitudinal river must have existed along its base. This river probably corresponded with the 'Indobrahm' of Pascoe and Pilgrim, but the distribution of fishes shows that it must have extended towards the Far East. From the distribution of various fishes the probable phases of dismemberment of this river are indicated, and it is explained how the Himalayas became divided hydrographically into three main divisions—the Brahmaputra, the Ganges and the Indus drainage systems.

The almost total dissimilarity between the northern and the southern Himalayan fishes is indicated, and it is concluded therefrom that the present-day drainage pattern of the Himalayas cannot have resulted from an antecedent drainage, according to which the Himalayan range is considered to have risen up across the rivers which kept their original channels open by vigorous erosion, but is the result of consequent drainage, of which the southern rivers captured the rivers of the north secondarily.

SCIENTIFIC RESULTS OF THE YALE NORTH INDIA EXPEDITION.

Biological Report No. 21.

Aquatic and Amphibious Molluscs.

By Baini Prashad, *D.Sc., F.R.S.E., F.R.A.S.B., F.L.S., F.Z.S., F.N.I., M.B.O.U., Director, Zoological Survey of India, Calcutta.*

Introduction.

Mr. G. E. Hutchinson, the biologist attached to the Yale North India Expedition, entrusted to me for report the collection of freshwater molluscs, including amphibious molluscs of the family Succineidae. The collection was made mainly in the Kashmir Valley and Western Tibet and comprises representatives of the families Valvatidae, Amnicolidae, Lymnaeidae, Planorbidae, Succineidae, and Corbiculidae. As was to be expected, the fauna of this area is entirely Palaearctic; almost all the species represented are truly Palaearctic forms, but in a few cases special local races of some of the species have evolved in the area under consideration.

In all 17 species are represented in the collection and in the case of two species of the genus *Lymnaea* a number of distinct forms were found in the collection.

The main interest of the collection is a new species of the genus *Sphaerium* which I describe below as *Sphaerium kashmirensis*. Another species is represented by two young shells, but with the limited material available I have not considered it right to describe it as new.

In the case of all species, as complete references as possible to the literature dealing with molluscs of the area under consideration are given. References to monographic works in which detailed accounts of the different species are already available, are also included.

In addition to the collections made in the Kashmir Valley and Western Tibet, Mr. Hutchinson collected a few molluscs at Calcutta, some places in the Punjab and in the Nilgiri Hills. These are dealt with in the Appendix at the end of the paper.

My sincere thanks are due to Mr. G. E. Hutchinson for affording me the opportunity of studying this interesting collection. I have also to offer my apologies for the delay in the preparation of the report, but this has been inevitable owing to pressure of official work.

GASTROPODA.

Subclass *PROSOBRANCHIA*.

Family Valvatidae.

Thiele[1] in his monograph included *Andrusovia* Brusina[2] from the Caspian Sea with *Valvata* O. F. Müller as a second genus of the family

[1] Thiele, J. *Handb. Syst. Weichtierk.* I, p. 121 (1929).

[2] Brusina in Westerlund, C. A. *Rad. Jugoslav. Akad.* CLI, p. 133 (1903). I have not seen this work.

Valvatidae. In the same work he has suggested dividing the genus *Valvata*, as generally accepted by most workers, into a number of sections. I, however, am not adopting this division, as the differences between the various sections do not seem to be sufficiently marked for assigning the species to these sections.

Genus **Valvata** O. F. Müller.

1774. *Valvata*, Müller, *Verm. Terr. Fluv. Hist.* II, p. 198.
1926. *Valvata*, Kennard & Woodward, *Synonymy Brit. Non-Marine Moll.* p. 27.
1927. *Valvata*, Pilsbry & Bequaert, *Bull. Amer. Mus. Nat. Hist.* LIII, p. 243.

For the synonymy of the genus reference may be made to Kennard and Woodward, while the characteristics of the animal and shell are described in detail by Pilsbry and Bequaert.

In the collection before me the genus is represented by *V. piscinalis* (Müller), which is widely distributed in Europe, Asia Minor, Northern Asia and Kashmir.

Valvata piscinalis (O. F. Müller).

1774. *Nerita piscinalis*, Müller, *Verm. Terr. Fluv. Hist.* II, p. 172.
1878. *Valvata piscinalis*, Nevill, *Sci. Res. Second Yarkand Mission, Mollusca*, p. 12.
1882. *Valvata piscinalis* var. *ambigua*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg* (7) XXX (No. 11), p. 48.
1910. *Valvata piscinalis*, Weber, *Zool. Jahrb. Syst.* XXIX, p. 307.
1926. *Valvata piscinalis*, Kennard & Woodward, *Synonymy British Non-Marine Moll.* p. 27.
1935. *Valvata piscinalis*, Mozley, *Trans. Roy. Soc. Edinburgh*, LVIII, p. 612, pl. ii, fig. 7.

Valvata piscinalis is represented in the collection from the following localities :—

K 5(2) . .	Bren Spur, Lokut Dal Lake, Kashmir; alt. *ca.* 5,200 ft. (Bren terrace exposure).	8 complete and a broken shell.
—	Same locality	3 large well preserved but weathered shells.
K 10(2) . .	Exposure along bank of Jhelum River below Pampur, Kashmir; alt. *ca.* 5,200 ft. Lower Shell-Bed. 25.iii.32.	2 complete shells embedded in dried mud, with a fragmentary shell of *Lymnaea* sp.
K 24 . .	Nishat Bagh, Kashmir; alt. *ca.* 5,200 ft. In a pond. 7.iv.32.	4 fresh shells.
K 42(*a*) . .	Wular Lake, Kashmir: alt. *ca.* 5,180 ft. Littoral at Kiuhnus. 17.iv.32.	1 fresh shell.
K 42(*b*) . .	Also dredged in 1·5-2 metres of water. 18. iv. 32.	15 fresh specimens.
—	Top Shell-Bed between Man and Spangmik near Panggong Tso, W. Tibet. 1. vii. 32.	5 bleached shells.

The specimens from the pond at Nishat Bagh—St. K. 24, those collected from the littoral zone of the Wular Lake (K 42*a*) and those dredged in the same Lake from a depth of 1·5-2 metres, are of a greenish colour with the surface rather dull and rough. They agree in all respects with European specimens and shells from the Pankong Lake, Yarkand, recorded by Nevill.

The specimens from Bren Spur, Lokut Dal Lake—St. K 5(2)—are all weathered shells, mostly well preserved, which were dug out of dried earth. These specimens resemble the ones from Nishat Bagh, but are somewhat larger in size.

The five shells from the Top Shell-Bed between Man and Spangmik near Panggong Tso, W. Tibet, are all bleached and partly weathered.

Family AMNICOLIDAE.

I have followed Pilsbry and Bequaert[1] in adopting the family name Amnicolidae for Hydrobiidae and Paludestrinidae of older authors. This very large family is found almost all over the world, more particularly in the temperate and tropical zones.

In the collections before me it is represented by two subgenera of *Bulimus* Scopoli, *Bulimus* s. s. and *Alcinma* Annandale & Prashad. The genus *Bulimus* is a representative of the subfamily Buliminae, members of which are distinguished by the possession of a solid, mainly calcareous, and largely concentric operculum which is too large for retraction into the peristome, and is, therefore, lodged at its edge.

Genus **Bulimus** Scopoli.

1777. *Bulimus*, Scopoli, *Introd. Hist. Nat.* p. 392.
1927. *Bulimus*, Pilsbry & Bequaert, *Bull. Amer. Mus. Nat. Hist.* LIII.
1928. *Bulimus*, Rao, *Rec. Ind. Mus.* XXX, p. 427.
1929. *Bithynia*, Rao, *Rec. Ind. Mus.* XXXI, p. 283.

Pilsbry and Bequaert gave detailed reasons for adopting *Bulimus* Scopoli in preference to *Bithynia* Leach, and selected *Helix tentaculata* Linn. as its genus type. Kennard & Woodward[2] had a few years earlier, after reviewing the opinions of other workers, suggested that " *Bulimus* was an obvious mistranscription for *Bulinus* ; it must be treated as such, and discarded in future literature ". In view of this Rao reverted to *Bithynia* in place of *Bulimus* in his second paper cited above. The matter was referred to the International Commission on Zoological literature, by Dr. H. A. Pilsbry, and in accordance with its decision, Opinion 116, *Bulimus* Scopoli with its genotype *Helix tentaculata* as selected by Pilsbry & Bequaert must replace *Bithynia* Leach 1818 with the same genotype.

Bulimus tentaculatus (Linn.).

var. **kashmiriensis** Nevill.

1885. *Bithynia tentaculata* var. *kashmiriensis*, Nevill, *Hand-List Moll. Ind. Mus.* II, p. 39.
1925. *Bithynia tentaculata* var. *kashmiriensis*, Prashad, *Rec. Geol. Surv. Ind.* LVI, p. 358, pl. XXIX, figs. 2-5.

A detailed synonymy of the typical form is published by Kennard & Woodward[3], and a good description with figures is to be found in

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[1] Pilsbry, H. A. & Bequaert, J. *Bull. Amer. Mus. Nat. Hist.* LIII, p. 212 (1927).
[2] Kennard, A. S. & Woodward, B. B. *Proc. Malacol. Soc. London,* XVI, pp. 125, 126 (1927).
[3] Kennard, A. S. & Woodward, B. B. *Synonymy Brit. Non-Marine Mollusca,* pp. 14-16 (1926).

Moquin-Tandon[1]. Mozley[2] in recording the species from Northern Asia gives the geographical range of the species as "Europe; Northern Asia, Kashmir, Punjab east of the River Indus, Annandale & Rao (1923); parts of North America, both living and in Pleistocene deposits, Baker (1928)". Other important references to the species are given in my part cited above.

As was stated in my paper cited above, Nevill gave the new name *kashmiriensis*, with measurements of a specimen, to a variety of *Bithynia tentaculata* which he recorded from Kashmir and Srinagar. In the above paper I also published the diagnostic characters and photographs of Nevill's variety from Kashmir.

The species is represented in the collection from the following localities:—

K 42 . .	Wular Lake, Kashmir; alt. *ca.* 5,180 ft. Littoral at Kiuhnus. 17.iv.32.	3 specimens.
K 46 . .	Bakh Hajan, Kashmir; alt. *ca.* 5,170 ft. *Jhil.* 19.iv.32.	13 specimens.

The fresh shells from both the localities are of a dull brownish green colour, with the growth lines rather feebly marked, but regular; the suture is more deeply impressed than in the typical form, and the whorls are more tumid. The umbilical chink, though minute, is also more marked than in the typical form.

Nevill gives the measurements of his specimen as "Length 7, diam. 4½ mil." The measurements of the largest specimen from the Wular Lake are 5·4 mm. × 3·8 mm. and of one from Bakh Hajan *Jhil* 6·3 mm. × 4·2 mm.

Subclass *PULMONATA*.

Family LYMNAEIDAE.

Genus **Lymnaea** Lam.

1799. *Lymnaea*, Lamarck, *Prodr. Nouv. Clas. Coq.* p. 75.
1911. *Lymnaea*, Baker, *Chicago Acad. Sci.*, Sp. Publ. III, p. 134.
1925. *Limnaea*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 146.

The synonymy and diagnostic characters of the genus *Lymnae* are discussed at length in the works of Baker and Annandale & Rao, and it is not necessary, therefore, to deal with them here.

In the collections of the Yale North India Expedition the genus is represented by the subgenera or groups:—

Lymnaea s. s.—genotype *L. stagnalis* (Linn.);
Radix Montfort—genotype *L. auriclaria* (Linn.); and
Galba Schrank—genotype *L. truncatula* (Müll.).

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[1] Moquin-Tandon, A. *Hist. Moll. France*, II, pp. 528, 529, pl. xxxix, figs. 23-44 (1856).
[2] Mozley, A. *Trans. Roy. Soc. Edinburgh*, LVIII, pp. 608, 609 (1935).

Subgenus **Lymnaea** s. s.

Lymnaea stagnalis (Linn.).

1758. *Helix stagnalis*, Linné, *Syst. Nat.* (Ed. X), p. 774.
1882. *Limnaea stagnalis*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 32.
1911. *Lymnaea stagnalis*, Baker, *Chicago Acad. Sci.*, Sp. Publ. III, p. 136.
1913. *Limnaea stagnalis*, Weber, *Abhandl. König. Bay. Akad. Wiss.* (*Math.-phys. kl.*) XXVI, p. 20.
1915. *Limnaea stagnalis*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 106.
1925. *Limnaea stagnalis*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 147.
1935. *Lymnaea stagnalis*, Mozley, *Trans. Roy. Soc. Edinburgh*, LVIII, p. 615.

Mozley has recently resummarised the geographical range of the species as "the whole of Europe, except Iceland ; North Africa ; Northern Asia as well as Afghanistan and Kashmir ; and the greater part of North America to the north of 40°". Other references to the occurrence of the species in Central Asia and particularly in the Kashmir area are summarised in my notes incorporated in Annandale and Rao's paper cited above. In the collections of the Yale North India Expedition the species is represented by the forms *kashmiriensis* Prashad and *minor* Kobelt.

Form **kashmiriensis** Prashad.

1925. *Limnaea stagnalis* race *kashmiriensis*, Prashad in Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 148, figs. V, 9, 10.

The race *kashmiriensis* was described by me in the paper cited above, and its anatomy was dealt with by Annandale and Rao in the same paper.

This race was found to be widely distributed in the lakes of Kashmir, and in the collection under report it is represented from the following stations :—

K 19 .	Gagribal, Kashmir ; alt. *ca.* 5,190 ft. Closed swamp. 31.iii.32.	13 specimens in spirit.
K 15 .	Same locality	2 dried shells.

These specimens resemble in all respects the earlier collections from Kashmir. The measurements of the largest specimen are :— Length 40 mm. ; breadth 22 mm. ; length of aperture 24 mm. ; breadth of aperture 12·5 mm. A number of very young specimens in the collection seems to indicate that the animals must have been breeding about the time (March) they were collected.

Form **minor** Kobelt.

1925. *Limnaea stagnalis* form *minor*, Prashad in Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 150, fig. V, 8.

For synonymy and description of this race reference may be made to my notes in the publication cited above. In the Indian Museum it is represented from a pool at Srinagar, Kashmir, and from Shandur Lake, Shandur Pass between Chitral and Gilgit, at an elevation of 12,300 ft.

The Yale North India Expedition collected specimens of this race from the following station :—

K 46 .	Bakh Hajan, Kashmir ; alt. *ca.* 5, 170 ft. *Jhil.*	3 specimens in spirit.

Subgenus **Radix** Montfort.

1910. *Radix*, Montfort, *Conch. Syst.* II, p. 266.
1911. *Radix*, Baker, *Chicago Acad. Sci.*, Sp. Publ. III, p. 178.
1915. *Gulnaria*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 110.
1925. *Radix*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 150.

For detailed characters of this subgenus reference may be made to Baker's work cited above. The type of the subgenus is the widely distributed Palaearctic species *L. auricularia* (Linn.).

Annandale & Rao recorded from India the following four species of the subgenus :—*L. auricularia* (Linn.), *L. lagotis* (Schrank), *L. persica* Issel and *L. brevicauda* Sowerby. In the collections made by the Yale North India Expedition there are representatives of all these species except *L.* persica.

Lymnaea auricularia (Linn.).

1758. *Helix auricularia*, Linné, *Syst. Nat.* (Ed. X), p. 774.
1877. *Limnaea auricularia* var. *ventricosa*, Kobelt in *Rossmässler Icon. Land Süssw. Moll.* V, p. 40, pl. cxxix, fig. 1244.
1878. *Limnaea auricularia* var., Nevill, *Sci. Res. Second Yarkand Mission, Mollusca*, p. 6.
1882. *Limnaea auricularia* var. *ventricosa*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 33, pl. iv, figs. 3, 4.
1910. *Limnaea (Gulnaria) auricularia* var. *ventricosa*, Weber, *Zool. Jahrb. Syst.* XXIX, p. 501.
1913. *Limnaea auricularia* var. *ventricosa*, Weber, *Abhandl. König. Bay. Akad. Wiss.* (*Math.-phys. kl.*), XXVI, p. 23.
1925. *Limnaea auricularia*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 158, figs. 1, 2, 4.
1935. *Lymnaea* (*Radix*) *auricularia*, Mozley, *Trans. Roy. Soc. Edinburgh*, LVIII, p. 620.

Mozley summarised the known distribution of this species as " Europe, as far south as Spain and Italy; Northern Asia ; Afghanistan; Kashmir ". Annandale & Rao recorded it from the Kashmir Valley.

In the collections made by the Yale North India Expedition there are a series of specimens from the following two localities :—

K 5(2) .	Bren Spur, Lokut Dal Lake, Kashmir ; alt. *ca.* 5,200 ft. Exposure Shell-Bed. 31. iii. 32.	2 broken, bleached shells.
L 58 .	Kyam ; Western Tibet ; alt. 15,630 ft. Hot Spring.	Many specimens in spirit.

The two broken shells from the " Exposure Shell-Bed " at Bren Spur can be assigned only doubtfully to this species, but the form of the spire, the suture and the remains of the body-whorl have led me to this identification.

The series of specimens from the hot spring at Kyam are all of a small size not exceeding 23 mm. in total length, and the shells of most specimens have a fairly thick, closely adhering encrustation of a brownish colour.

The shell is globose, thin, light brownish with the surface rather smooth and shining ; the last or body-whorl appears in some shells to be finely ribbed. Whorls about $3\frac{1}{2}$-4, convex, all well rounded, the last well expanded especially along the superior margin ; spire very small, acutely pointed ; suture deeply impressed, almost channeled ; aperture large, ovate, columella gently curved, becoming greatly twisted over the umbilical chink.

At first I had some doubt about assigning the Kyam specimens to *L. auricularia*, but after carefully comparing them with specimens from various localities in the collections of the Indian Museum I have come to the conclusion that they represent a dwarfed form of the species, probably produced as a result of the peculiar biological conditions prevailing in the hot spring.

Lymnaea lagotis (Schrank).

1803. *Buccinum lagotis*, Schrank, *Fauna Boica*, III, p. 290.
1874. *Limnaea lagotis*, von Martens in *Fedtschenko's Reise in Turkestan, Mollusca*, p. 26, pl. ii, fig. 22.
1878. *Limnaea lagotis* (in part), Nevill, *Sci. Res. Second Mission, Mollusca*, p. 7.
1882. *Limnaea lagotis*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 34.
1904. *Limnaea (Radix) lagotis*, Kobelt in *Rossmässler Icon. Land Süssw. Moll.* (N. F.) XI, p. 239.
1911. *Limnaea (Gulnaria) lagotis*, Andreae in *Futterer Durch Asien*, III, p. 75.
1913. *Limnaea lagotis*, Weber, *Abhandl. König. Bay. Akad. Wiss. (Math.-phys. kl.)*, XXVI, p. 24.
1925. *Limnaea lagotis*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 151.

Annandale & Rao in their paper cited above have discussed at length the differences between the shells of *L. auricularia* and *L. lagotis* and described the five forms of the latter species which occur within Indian limits. Four of these, *viz.*, *striata* Andreae, *costulata* von Martens, *solidissima* Kobelt and *defilippii* Issel are represented in the collections of the Yale North India Expedition.

Form **striata** Andreae.

1911. *Limnaea (Gulnaria) lagotis* var. *striata*, Andreae in *Futterer Durch Asien*, III, p. 75, fig.
1913. *Limnaea lagotis* var. *striata* Weber, *Abhandl. König. Bay Akad. Wiss. (Math.-phys. kl.)*, XXVI, p. 24, pl. i, figs. 10a-d, f. h.
1925. *Limnaea lagotis* form *striata*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 153, fig. 1, 1.

Andreae remarked that his new var. *striata* from Sulai-ho in the Gobi Desert appears to be identical with the form recorded as *L. plicatula* Bens. var. *fasciolata* by von Martens[1] from Kuko-Nur. He, however, considered his form to be a variety of *L. lagotis*, and this was confirmed by Weber and Annandale & Rao.

In young shells of this form, as is clearly shown by Andreae's figures, there is fairly prominent spire, but in older shells (see figure in Annandale & Rao) the spire is very short as compared to the total length of the shell. The mouth is ovoid in the young stages, but becomes semicircular to auriculate in the adult. The shell bears fine vertical striae.

In the collections of the Yale North India Expedition it is represented from the following localities :—

K 21 .	Dal Lake, Kashmir; alt. *ca.* 5,190 ft., in about 1·25 metres of water. 11. iv. 32.	3 specimens.
K 46 .	Bakh Hajan, Kashmir; alt. *ca.* 5,170 ft. *Jhil.* 19. iv. 32.	4 specimens.
L 16 .	Spitok, Kashmir; alt. *ca.* 10,730 ft. Deepest pond. 9. vi. 32.	5 shells.

[1] von Martens, E.—*Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 38, pl. iv, fig. 10.(1882).

From **costulata** von Martens.

1874. *Limnaea lagotis* var. *costulata*, von Martens, *Fedtschenko's Reise in Turkestan, Mollusca*, p. 26, pl. ii, fig. 24.
1878. *Limnaea lagotis* var. *costulata*, Nevill, *Sci. Res. Second Mission, Mollusca*, p. 8.
1882. *Limnaea lagotis* var. *costulata*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 50.
1925. *Limnaea lagotis* var. *costulata*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 153, fig. I, 7.

This form was described by von Martens as a variety of *L. lagotis* from shells collected in "Saissan-Sea," and was later recorded by Nevill from Leh. Nevill further remarked that the form figured by von Martens (fig. 22) as *L. lagotis* also belonged to this form; in the specimens from Leh he found specimens which formed "every conceivable connecting link," though the columella "graduates from even a more rounded shape than figure 22 B to the straight (or slightly bent-back) form of figure 24 A." Weber[1] considered both the varieties *costulata* and *subdisjuncta* of von Martens to be only variations of *striata* Andreae. Annandale & Rao, with whose conclusions I agree, however, considered this form to differ from *striata* Andreae in its longer spire and having the mouth less expanded and less variable in shape. The columellar fold is, further, a little broader than in the var. *striata*.

In the collections of the Yale North India Expedition this form is represented from the following localities:—

K 15, 19	Gagribal, Kashmir; alt. *ca.* 5,190 ft. Closed swamp. 31. iii. 32.	7 specimens.
L 14 .	Spitok, Kashmir; alt. *ca.* 10,730 ft. 4. vii. 32.	1 specimen.
L 38 .	3 miles west of Mugleb, W. Tibet; alt. *ca.* 13,700 ft. Drying pool with *Potamogeton*. 27. vi. 32.	15 specimens.
L 73 .	Chushol, W. Tibet; alt. *ca.* 13,700 ft. 2nd pond below village. 9. viii. 32.	3 specimens.

Form **solidissima** Kobelt.

1872. *Limnaea lagotis* var. *solidissima*, Kobelt, *Malakozool, Blätt.* XIX, p. 77, pl. ii, figs. 17, 18.
1877. *Limnaea lagotis* var. *solidissima*, Kobelt in *Rossmässler Icon. Land Süssw. Moll.* V, p. 38, pl. cxviii, fig. 1242.
1878. *Limnaea lagotis* (in part), Nevill, *Sci. Res. Second Yarkand Mission, Mollusca*, p. 7.
1925. *Limnaea lagotis* var. *solidissima*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 154, figs. I, 3, 5.

Kobelt in describing the var. *solidissima* from a shell from the Himalayas remarked "Ueber das vorkommen dieser Form habe ich genaueres leider in Erfahrung bringen können; wahrscheinlich sind die Verhaltnisse denen ähnlich, unter welchen *L. obliquata* vorkommt, und mit Sicherheit glaube ich ihre Heimath in einem See suchen zu müssen." Nevill surmised that Kobelt's type-specimen of the var. *solidissima* probably came from Lake Pankong. He apparently considered *solidissima* to be a variety of *L. lagotis*, but from this account it is not clear

[1] Weber, A.—*Abhandl. Konig, Bay. Akad. Wiss. (Math. phys. kl.)*, XXVI, p. 25, (1913).

as to whether he is dealing with the typical form of *L. lagotis* or the var. *solidissima*. Annandale & Rao remarked on the great variability of this thick-shelled form and added that "it probably lives in water of abnormal chemical composition." The figures of Kobelt represent a young shell, while very good figures of two adult shells showing the major variations in the form of the spire and the mouth aperture are published in Annandale & Rao's paper.

This form is represented in the collections of the Yale North India Expedition from the following localities :—

L 39	. Tsar Tso, W. Tibet ; alt. 13,950 ft. 28. vi. 32.	3 specimens.
L 40	. Panggong Tso, W. Tibet ; alt. 13,915 ft. "Upper Shell-Bed under Moraine," 28.vi.32.	17 shells (mostly bleached).
	Top Shell-Bed between Man-Spangmik, W. Tibet ; bottom shore about 1 mile from western bare end. 1.vii.32.	21 shells.
	Top Shell-Bed at Man, W. Tibet. 5.vii. 32.	12 shells.
L 72	. Chushol, W. Tibet ; alt. 14,228 ft. Large pond. 1.viii.32.	1 specimen.
	Near L 72. 14.vii.32 . . .	2 specimens.

Form **defilippii** Issel.

1865. *Limnaea defilippi*, Issel, *Mem. Real. Accad. Sci. Torino*, (2) XXIII, p. 45, pl. iii, figs. 62, 63.

1925. *Limnaea lagotis* var. *defilippi*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 156, fig. I, 9.

Issel in describing his species from Lake Goktscha (alt. 5,500 ft.) in Armenia remarked that it appears to be intermediate between *L. stagnalis* and *L. auricularia*, while von Martens in the *Zoological Record* for 1865 (p. 279) added "almost too closely allied to *L. stagnalis* L." Nevill[1] in describing a new variety, *sirikulensis*, remarked "This is perhaps the most remarkable of the Yarkand species of *Limnaea* and the further removed from the typical forms of *L. auricularia* and *L. lagotis*, even more so than typical *L. defilippi*. As justly pointed out by Issel, it is intermediate between the above group and that of *L. stagnalis*." Annandale & Rao rightly considered Issel's species to be a form of *L. lagotis*, and after remarking on its general resemblance to the form *subdisjuncta* Nevill[2] stated that it is distinguished by its larger and more fragile shell and an additional whorl in the spire.

The specimens, which I assign to this form, have an elongate, scalariform spire distinctly marked off from the moderately tumid body-whorl ; in some specimens the spire is more elongate than others, while in others with a more channeled suture it is somewhat sunk into the body-whorl. The suture is generally moderately impressed and greatly slanting towards the posterior end of the mouth. The surface of the shells bears vertical costae almost as strong as in the form *costulata* von Martens, and in addition is decussately malleated, particularly in the region of

[1] Nevill, G.—*Sci. Res. Second Yarkand Mission, Mollusca*, p. 7 (1878).

[2] Nevill, G.—*op. cit.* p. 9 (1878).

the body-whorl. The aperture is more or less ovate with its outer margin almost regularly arched. I give below the measurements (in millimetres) of three specimens from an irrigation trench at Rampur (St. K 1):—

Total length	19	18·6	18
Maximum breadth	14·4	14·7	14·5
Length of aperture	12·8	14	14
Breadth of aperture	10·2	10·5	11
Length of spire (dorsal)	5·8	4·5	4·8
Breadth of base of spire	6	5·8	5·5

This form is represented in the collections of the Yale North India Expedition from :—

K 1	Rampur, Kashmir; alt. *ca.* 4,000 ft. In irrigation trench and fields. 18.iii. 32.	13 specimens in spirit.
K 34	Phashakuri near Pampur, Kashmir; alt. *ca.* 5,200 ft. 7. v. 32.	3 dry shells.

Lymnaea brevicauda Sowerby.

1873. *Limnaea brevicauda*, Reeve, *Conch. Icon.* XVIII, pl. xv, sp. 105.
1876. *Limnaea brevicauda*, Hanley & Theobald, *Conch. Ind.* p. 64, pl. clvii, fig. 7.
1915. *Limnaea* (*Gulnaria*) *brevicauda*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 111.
1925. *Limnaea brevicauda*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 156, fig. 1, 6.

As pointed out by Annandale & Rao "this is one of the commonest molluscs in the lakes of the Kashmir Valley, to which the species is perhaps confined." The type-specimen was stated by Sowerby to be from Australia, but the error was corrected by Hanley & Theobald. The anatomy and relationships of the species are discussed in detail by Annandale & Rao.

In the collections of the Yale North India Expedition the species is represented from :—

K 3	Lokut Dal Lake, Kashmir; alt. 5,190 ft.	5 specimens in spirit.
K 42	Wular Lake, Kashmir; alt. 5,160 ft.	21 specimens (13 in spirit, 8 dry shells).

Subgenus **Galba** Schrank.

1803. *Galba*, Schrank, *Fauna Boica*, III, pt. 2, pp. 262, 285.
1911. *Galba* (in part), Baker, *Chicago Acad. Sci.*, Sp. Publ. III, p. 199.
1925. *Galba*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 161.
1926. *Galba*. Kennard & Woodward, *Synonymy Brit. Non-Marine Moll.* p. 42.

The synonymy of the subgenus *Galba* is dealt with at length by Kennard & Woodward. I follow Annandale & Rao in restricting this subgenus to forms which can be distinguished by the great development of the columellar fold of the shell.

In the collection under report the subgenus is represented by the type-species *L. truncatula* (Mull.).

Lymnaea truncatula (Müll.).

1774. *Buccinum truncatulum*, Müller, *Verm. Terr. Fluv. Hist.* II, p. 130.
1862. *Limnaeus truncatulus*, Küster in *Martini Chemnitz Conch. Cab.* I, Ab. 17b, *Limnaeus* etc, p. 17, pl. iii, figs. 24-27.
1878. *Limnaea truncatula* (in part) Nevill, *Sci. Res. Second Yarkand Mission*, Mollusca, p. 10.
1882. *Limnaea truncatula*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 41.
1911. *Limnaea* (*Limnophysa*) *truncatula*, Andreae in *Futterer Durch Asien*, III, p. 77.
1925. *Limnaea truncatula*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 161, fig. V, 3, 4, 5.
1926. *Limnaea* (*Galba*) *truncatula*, Kennard & Woodward, *Synonymy Brit. Non-Marine Moll.* p. 59.
1935. *Lymnaea* (*Galba*) *truncatula*, Mozley, *Trans. Roy. Soc. Edinburgh*, LVIII, p. 630.

Mozley sums up the geographical range of the species as " Europe including Iceland, Northern Africa ; Northern Asia, Afghanistan, Kashmir ; Alaska, Aleutin Islands, Yukon." Annandale & Rao recorded it from Leh in Little Tibet and from Chitral.

In the collections of the Yale North India Expedition the species is represented from the following localities : --

K 77	. Dras, Kashmir ; alt. 10,144 ft. In a stream. 22. v. 32.	7 specimens.
L 3	. Kangral, Kashmir ; alt. *ca.* 11,100 ft. 27 v. 32.	6 specimens.
L 14	. Spitok, Kashmir ; alt. 10,730 ft. 4. vi. 32.	17 specimens.
L 18	. Gulam Bagh, Chushod, Kashmir ; alt. *ca.* 10,600 ft. In a pond. 10. vi. 32.	5 specimens.
L 19	. 2 miles east of L 18 ; alt. *ca.* 10,600 ft. 10. vi. 32.	4 specimens.

All the above collecting stations are situated in Kashmir in the area adjoining Western Tibet.

Family PLANORBIDAE.

Genus **Planorbis** Geoffroy.

1767. *Planorbis*, Geoffroy, *Traité Coq.* p. 12.
1774. *Planorbis*, Müller, *Verm. Terr. Fluv. Hist.* II, p. 152.
1905. *Planorbis*, Dall, *Harriman Alaska Exped.* XIII, p. 80.
1921. *Planorbis*, Germain, *Rec. Ind. Mus.* XXI, p. 1.
1922. *Planorbis*, Annandale, *Rec. Ind. Mus.* XXIV, p. 360.
1924. *Planorbis*, Kennard & Woodward, *Proc. Malacol. Soc. London*, XVI, p. 9.
1925. *Planorbis*, Kennard & Woodward, *Synonymy Brit. Non-Marine Moll.* p. 66.
1931. *Planorbis*, Baker, *Proc. Zool. Soc. London*, p. 583.

As is clear from the publications cited above, there has been a great deal of difference of opinion regarding the genotype of *Planorbis* and the author to whom this genus should be assigned. Kennard & Woodward consider Geoffroy (1767) as the author of the genus with *Planorbis planorbis* (Linn.) as its genotype, while Dall, Germain and recently Baker, who has discussed the question at length, all assign the genus *Planorbis* to Müller and regard *Planorbis corneus* (Linn.) as its genotype. I follow Kennard & Woodward in the following notes.

Planorbis planorbis (Linn.).

Var. **tangitarensis** Germain.

1878. *Planorbis (Anisus) subangulatus* (?) var. (? n. species), Nevill, *Hand-List Moll. Ind. Mus.* Ik p. 243.
1878. *Planorbis (Tropidiscus) subangulatus* var., *Nevill, Sci. Res. Second Yarkand Mission, Mollusca*, p. 11.
1918. *Planorbis (Tropidiscus) planorbis* var. *tangitarensis*, Germain, *Bull. Mus. Hist. Nat. Paris*, XXIV, p. 276.
1921. *Planorbis (Tropidiscus) planorbis* var. *tangitarensis*, Germain, *Rec. Ind. Mus.* XXI, p. 77, pl. iv, figs. 3, 4, 8.

Germain's account may be consulted for a detailed description of this interesting variety. It was described from specimens collected by the Second Yarkand Expedition at North Tangitar.

The Yale North India Expedition collected 18 specimens at St. K 24—Nishat Bagh, Kashmir ; alt. *ca.* 5,200 ft.; in a pond. These specimens agree in all respects with the types of the variety from North Tangitar.

I also assign, with some doubt, 3 incomplete casts of shells collected from St. K 10(2)—Pampur, Kashmir ; alt. *ca.* 5,200 ft. Exposure along the Jhelum River opposite Island north of Pampur ; 4. iii. 32.

Genus **Gyraulus** Charpentier.

1837. *Gyraulus*, Agassiz *Ms.* in De Charpentier, *Denkschr. Schweiz. Gessel. Nat. Neuchatel*, I, p. 21.
1922. *Gyraulus*, Germain, *Rec. Ind. Mus.* XXI, p. 98.
1922. *Gyraulus*, Annandale, *Rec. Ind. Mus.* XXIV, p. 361.

Germain regards *Gyraulus* Agassiz as a subgenus of *Planorbis* Mull., but I follow Annandale in classing it as distinct genus.

Gyraulus pankongensis (Nevill) von Martens.

1878. *Planorbis (Gyraulus) albus* (in part), Nevill, *Hand-List Moll. Ind. Mus.* I, p. 245.
1878. *Planorbis (Gyraulus) albus* var. Nevill, *Sci. Res. Second Yarkand Mission, Mollusca*, p. 10.
1882. *Planorbis Pankongensis*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 45, pl. iv, figs. 14*a-c*.
1890. *Planorbis (Gyraulus) pankongensis*, Westerlund, *Faun. Paläarct. Region Binnenconch*, Suppl. 1, p. 149.
1910. *Planoris (Gyraulus) pankongensis*, Weber, *Zool. Jahrb. (Syst.)* XXIX, p. 306.
1918. *Planorbis (Gyraulus) pankongensis*, Germain, *Bull. Mus. Hist. Nat. Paris*, XXIV, p. 280.
1922. *Planorbis (Gyraulus) pankongensis*, Germain, *Rec. Ind. Mus.* XXI, p. 110,
1925. *Gyraulus pankongensis*, Prashad, *Rec. Geol. Surv. Ind.* LVI, p. 359.

Nevill, though he recorded the specimens from the Lake Pankong as *P. (G.) albus* var., had given them the manuscript name *pankongensis*, and it was under this name that the species was described by von Martens from material sent to him by Nevill. Weber recorded some specimens collected by Zugmayer from the same Lake as *P. (G.) pankongensis*, but considered it to be only a local form of *P. glaber* Jeffr. and not of *P. albus* Müll., as the specimens did not show any spiral sculpture. Germain discussed the species at great length and was of opinion that von Martens was not justified in comparing this species with the South American *P. andecolus* d'Orbigny or the African *P. choanomphalus* von Martens. He considered it to be allied to *G. ladacensis* Nevill, but suggested that

" par sa forme générale et son enroulement, plus étroitement apparenté aux *Gyraulus* de la fauna européenne."

The Yale North India Expedition collected specimens of the species from the following localities :—

K 10	. Pampur, Kashmir; alt. *ca.* 5,200 ft. Exposure along Jhelum river. 25. iii. 32.	7 complete, bleached shells.
K 34	. Phashakuri, Kashmir ; alt. *ca.* 5,200 ft. 7. v. 32.	9 specimens.
K 46	. Bakh Hajan, Kashmir ; alt. *ca.* 5,170 ft. *Jhil.* 19. iv. 32.	2 specimens.
L 14	. Spitok, Kashmir ; alt. *ca.* 10,600 ft. Marsh. 4. vi. 32.	6 specimens.
L 18	. Chushod, Kashmir ; alt. *ca.* 16,600 ft. Gulam Bagh. 10. vi. 32.	4 specimens.
L 19	. 2 miles east of L 18	3 specimens.
L 36	. Between Durbuk and Tangtse, W. Tibet ; alt. *ca.* 13,000 ft. In a pond.	8 specimens.
L 38	. Between Tangtse and Mugleb, W. Tibet ; alt. *ca.* 13,700 ft. 27. vi. 32.	12 specimens.
L 40	. Panggong Tso, W. Tibet ; alt. 13,915 ft. Upper Shell-Bed under moraine. 25. vi. 32.	51 shells, mostly bleached.

I have assigned the specimens from Stations K 10, K 34 and K 46 to this species with some doubt ; they may represent a distinct species, but the material at my disposal is not sufficient for deciding this point.

Gyraulus ladacensis Nevill.

1878. *Planorbis* (*Gyraulus*) *laevis* var. *ladacensis*, Nevill, *Sci. Res. Second Yarkand Mission, Mollusca*, p. 10.
1882. *Planorbis Nevilli*, von Martens, *Mem. Acad. Imp. Sci. St. Petersbourg*, (7) XXX, No. 11, p. 35.
1890. *Planorbis* (*Gyraulus*) *Nevilli*, Westerlund, *Faun. Paläarct. Region Bimenconch*, Suppl. I, p. 149.
1918. *Planorbis* (*Gyraulus*) *ladacensis*, Germain, *Bull. Mus. Hist. Paris*, XXIV, p. 278.
1921. *Planorbis* (*Gyraulus*) *ladacensis*, Germain, *Rec. Ind. Mus.* XXI, p. 112.

I have nothing to add to the detailed account of this species by Germain.

The Yale North India Expedition collected this species from the following localities :—

	Between Man-Spangmik, W. Tibet ; alt. *ca.* 14,000 ft. Top Shell-Bed. 1. vii. 32.	10 bleached shells.
L 47	. Lung-Yun, W. Tibet ; alt. 16,331 ft. Chagra Warm Spring. 8. vii. 32.	38 specimens.

Family SUCCINEIDAE.

Genus **Succinea** Draparnaud.

1801. *Succinea*, Draparnaud, *Tabl. Moll. Terr. Fluv. France*, p. 55.
1914. *Succinea*, Gude, *Faun. Brit. Ind. Mollusca* II (Trochomorphidae-Janellidae), p. 445.
1924. *Succinea*, Rao, *Rec. Ind. Mus.* XXVI, p. 377.

In the following notes on the specimens of the genus *Succinea* collected by the Yale North India Expedition, I have followed the excellent monograph of Rao cited above. All the specimens in the collection belong to the amphibious species, *Succinea indica* Pfeiffer.

Succinea indica Pfeiffer.

1849. *Succinea indica*, Pfeiffer, *Proc. Zool. Soc. London*, p. 133.
1914. *Succinea indica*, Gude, *Faun. Brit. Ind. Mollusca* II (Trochomorphidae-Janellidae), p. 447.
1924. *Succinea indica*, Rao, *Rec. Ind. Mus.* XXVI, p. 378, pl. xxviii, figs. 4-9.

Gude and Rao may be consulted for detailed information regarding the form of the shell and anatomy of this variable species.

The Yale North India Expedition collected shells of the species from the following localities :—

K 15, 19	Gagribal, Kashmir; alt. *ca.* 5,190 ft. Closed swamp. 31. iii. 32.	6 specimens.
K 34 .	Phashakuri, Kashmir; alt. *ca.* 5,200 ft. 7. v. 32.	3 specimens.
K 46 .	Bakh Hajan, Kashmir; alt. *ca.* 5,170 ft. *Jhil.* 19. iv. 32.	1 specimen.
K 51 .	Bod Dal. Kashmir. 2. v. 32 . .	5 specimens.

PELECYPODA.

Order *EULAMELLIBRANCHIATA*.

Family CORBICULIDAE.

In view of the fact that the generic name *Cyrena* Lam., as generally understood by most authors, is an absolute synonym of *Corbicula* Megerle,[1] Thiele[2] has suggested the family name Corbiculidae for Cyrenidae.

Genus **Corbicula** Megerle von Mühlfeldt.

1928. *Corbicula*, Prashad, *Mem. Ind. Mus.* IX, p. 14.

For the synonymy and distribution of the Asiatic species reference may be made to my paper cited above. In the collection before me the genus is represented by a single species—*C. cashmiriensis* Deshayes.

Corbicula cashmiriensis Deshayes.

1854. *Corbicula cashmiriensis*, Deshayes, *Proc. Zool. Soc. London*, p. 344.
1910. *Corbicula fluminalis* var. *oxiana*, *Weber*, *Zool. Jahrb. Syst.* XXIX, p. 308.
1928. *Corbicula cashmiriensis*, Prashad, *Mem. Ind. Mus.* IX, p. 20, pl. iii, figs. 14-18.

In my paper cited above I dealt with *C. cashmiriensis* in detail and pointed out the characters in which it differs from *C. fluminalis* (Müll.). The species, as pointed out in the paper cited above, is confined to Kashmir where it occurs in River Jhelum and the waters connected

[1] See Prashad B.—Lamellibranchia of the Siboga Expedition. Systematic Part II, Pelecypoda exclusive of the Pectinidae. *Siboga Expeditie*, LIIIc, p. 174 (1932).
[2] Thiele, J.—*Handb. Syst. Weichtierkunde*, II, p. 850 (1935).

with. Weber recorded specimens of the species from Wular Lake as *C. fluminalis* var. *oxiana*,

The Yale North India Expedition collected a single specimen of the species from St. K 1—Rampur, Kashmir ; alt. *ca.* 4,000 ft.; in an irrigation trench ; 18. iii. 32.

Genus **Pisidium** Pfeiffer.

1821. *Pisidium*, Pfeiffer, *Naturg. Deutsch. Moll.* I, pp. 17, 123.
1925. *Pisidium*, Prashad, *Rec. Ind. Mus.* XXVII, p. 407.
1933. *Pisidium*, Prashad, *Rec. Ind. Mus.* XXXV, pp. 1-8, pl. i.

The Indian and Tibetan species of the genus *Pisidium* are dealt with in detail in my papers cited above. The Yale North India Expedition collected the following species from Kashmir and Western Tibet :—*P. hydaspicola* Theobald, *P. zugmayeri* Weber, and *P. stoliczkanum* Prashad.

Pisidium hydaspicola Theobald.

1878. *Pisidium hydaspicola*, Theobald, *Journ. As. Soc. Bengal*, XLVII, p. 147.
1925. *Pisidium hydaspicola*, Prashad, *Rec. Ind. Mus.* XXVII, p. 414, pl. vii, figs. 5-7, pl. viii, fig. 5.

This species, which belongs to the subgenus *Eupisidium* Odhner, is confined to the Kashmir Valley. For detailed descriptions of the shell, animal and its distribution reference may be made to my paper cited above.

The Yale North India Expedition collected specimens of the species from the following localities :—

K 10 .	One mile north of Pampur, Kashmir ; alt. *ca.* 5,200 ft. Exposure along bank of Jhelum River. 25. iii. 32.	3 shells in dried mud.
K 24 .	Nishat Bagh, Kashmir ; alt. *ca.* 5,200 ft. Pond. 7. iv. 32.	20 specimens.

In addition there is a badly damaged shell from St. K 76—1 mile west of Dras, alt. *ca.* 10,000 ft., which probably also belongs to this species.

Pisidium stoliczkanum Prashad.

1933. *Pisidium stoliczkanum*, Prashad, *Rec. Ind. Mus.* XXXV, p. 5, pl. i, figs. 7, 8.

A detailed description of this interesting species from Yarkand was published in my paper cited above.

The Yale North India Expedition collected 5 valves from the Top Shell-Bed between Man-Spangmik, Western Tibet ; alt. *ca.* 14,000 ft. ; 1. vii. 37.

Pisidium zugmayeri Weber.

1910. *Pisidium* (*Fossarina*) *zugmayeri*, Weber, *Zool. Jahrb. Syst.* XXIX, p. 310.
1935. *Pisidium zugmayeri*, Prashad, *Rec. Ind. Mus.* XXXV, pl. i, figs. 1, 2.

This species was described from the Pankong Lake (Panggong Tso of Yale North India Expedition), Western Tibet, by Weber, while figures of the shell and hinge are published in my paper cited above.

The Yale North India Expedition collected with an Eckman Grab 2 complete shells and a right valve from St. L 78 —Yaye Tso, Western Tibet, alt. 15,373 ft.; 19.viii.32.

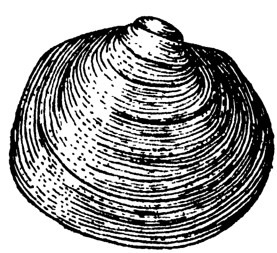
Genus **Sphaerium** Scopoli.

1777. *Sphaerium*, Scopoli, *Introd. Hist. Nat.* p. 397.
1921. *Sphaerium*, Prashad, *Rec. Ind. Mus.* XXII, p. 614.
1925. *Sphaerium*, Kennard & Woodward, *Synonymy Brit. Non-Marine Moll.* p. 300.
1927. *Sphaerium*, Pilsbry & Bequaert, *Bull. Amer. Mus. Nat. Hist.* LIII, p. 347.

Pilsbry & Bequaert are certainly wrong in stating that the genus *Sphaerium* is restricted mainly "to the Holarctic Region and is not known from the Oriental and Australian Regions." In the paper cited above I listed three species from India, *S. montanum* T. Canefri[1] from Burma, while *S. borneense* (Sowerby) and *S. cecilae* Prashad[2] are known from Borneo and Sumatra. The Yale North India Expedition collected a new species from the Wular Lake, Kashmir, which I describe below as *S. kashmirensis*.

Sphaerium kashmirensis, sp. nov.

Shell subquadrate, moderately swollen, sub-equilateral, moderately thick, anterior half of upper margin short, nearly straight, posterior part somewhat longer, markedly sloping; anterior margin evenly curving down to the very slightly arched lower margin; posterior margin slightly arched in the upper region, then sharply truncate. Umbones very prominent, very tumid, incurved, almost touching in the middle line. Epidermis of a light olive colour in the major part of the shell, of a yellowish colour along the margin, shining, with well marked, closely situated concentric striae, those in the regions of growth much better developed. Hinge apparently as in other species.



Type shell of *Sphaerium kashmirensis*, sp. nov. ×6.

Measurements (in millimetres).

	Holotype.	Single valve.
Length	6	5·8
Breadth	5·3	4·9
Thickness	3	..

[1] See Prashad, B.—*Rec. Ind. Mus.* XXII, p. 630, figs. 36, 37, (1921).
[2] Prashad, B.—*Rec. Ind. Mus.* XXII, p. 505, fig. 17, (1921).

Locality.—A complete shell, the holotype, and a left valve with a broken right valve were collected by the Yale North India Expedition at St. K 42—Wular Lake, Kashmir, alt. *ca.* 5,180 ft.; Kiuhnus, dredged in 0·5-10 metres of water, on 18.iv.32.

S. kashmirensis appears to be allied to *S. montanum* T. Canefri from Burma, but is relatively shorter, with its anterior and posterior margins straighter and its sculpture more strongly developed.

Sphaerium sp.

A young complete shell and a broken valve of a species were collected on 4.vii.32 by the Yale North India Expedition from a swamp at St. L 14—Spitok, Kashmir, alt. 10,730 ft.

The shells differ from *S. kashmirensis* in their being less quadrate, and they probably represent another species. With the very limited material available, I, however, do not propose describing it as a new species.

APPENDIX.

GASTROPODA.

Family AMNICOLIDAE.

Bulimus (Alocinma) stenothyroides (Dohrn).

1857. *Bithynia stenotyroides*, Dohrn, *Proc. Zool. Soc. London*, p. 123.
1870. *Bythinia stenothyroides*, Hanley & Theobald, *Conch. Ind.* p. 18.
1884. *Bythinia stenothyroides*, Nevill, *Hand-List Moll. Ind. Mus. II*, p. 37.
1915. *Bithynia stenothyroides*, Preston, *Faun. Brit. Ind., Freshw. Moll.* p. 77.
1920. *Amnicola (Alocinma) stenothyroides*, Annandale, *Rec. Ind. Mus.* XIX, p. 43.

Dohrn's *Bithynia stenothyroides* was assigned by Annandale to the subgenus *Alocinma* Annandale & Prashad[1] of the genus *Amnicola* Gould, but as Pilsbry & Bequaert[2] have shown, *Alocinma* is not related to *Amnicola*, but belongs to the subfamily Buliminae, and should be treated as a subgenus of *Bulimus* Scopoli.

This species is, as was remarked by Nevill, extremely variable in the form of the spire and whorls. Extreme forms are easily distinguished but intermediate types are hard to separate from the allied species.

In the collections made by the Yale North India Expedition the species is represented by two typical shells collected at St. N 6—a pool near milestone 4 on Marimund—Connamara Rd., alt. *ca.* 7,500 ft., Nilgiri Hills, Peninsular India.

The species, which was described from Ceylon, has a wide range in Peninsular India, having been recorded from Madras, Trichinopoly, South Arcot, the Nilgiris, and Poona.

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[1] Annandale, N. & Prashad, B.—*Rec. Ind. Mus.* XVIII, p. 23 (1919).
[2] Pilsbry, H. A. & Bequaert, J.—*Bull. Amer. Mus. Nat. Hist.* LIII, p. 213 (1927).

Family LYMNAEIDAE.

Genus **Lymnaea** Lam.

Subgenus **Pseudosuccinea** Baker.

1911. *Pseudosuccinea*, Baker, *Chicago Acad. Sci.*, Sp. Publ. III, p. 162.
1925. *Pseudosuccinea*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 171.

Specimens of two species of this subgenus, *viz.*, *L. acuminata* Lam. and *L. luteola* Lam. were collected by the Yale North India Expedition in the Punjab and the Nilgiri Hills.

Lymnaea acuminata Lam.

1822. *Lymnaea acuminata*, Lamarck, *Hist. Nat. Anim. saus Verteb.* VI (2), p. 160.
1858. *Lymnaea acuminata*, Lamarck, *Hist. Nat. Anim. saus Verteb.* (Ed. II), VIII, p. 411.
1922. *Lymnaea acuminata*, Annandale & Prashad, *Rec. Ind. Mus.* XXII, p. 568, pl. vii, figs. 1-3, text-fig. 12.
1925. *Limnaea acuminata*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, p. 177, fig. III.

The great variability in the form of the shell of this Indian species and its varieties is fully discussed by Annandale and Prashad and Annandale and Rao in the papers cited above.

In the collections of the Yale North India Expedition the species is represented by the forms :—*typica* Lam. and *hians* Sowerby.[1]

The exact localities for the two forms are as follows :—

Form **typica** Lam.

P 2	. Sohawa, Rawalpindi Dist., Punjab. 4.iii.32.	22 specimens.

Form **hians** Sowerby.

N 5	. Ootacamund, Nilgiri Hills, South India ; north margin of Lake. 8.xi.32.	3 specimens.

Lymnaea luteola Lamarck.

1822. *Lymnaea luteola*, Lamarck, *Hist. Nat. Anim. sans Verteb.* VI (2), p. 160.
1858. *Lymnaea luteola*, Lamarck, *Hist. Nat. Anim. sans Verteb.* (Ed. II), VIII, p. 411.
1925. *Limnaea luteola*, Annandale & Rao, *Rec. Ind. Mus.* XXVII, pp. 106, 183, fig. IV.

This interesting species is discussed in detail by Annandale and Rao in the papers referred to above. It is widely distributed in India, Burma and Ceylon.

In the collections of the Yale North India Expedition it is represented by the form *ovalis* Gray[2] from the following localities :—

	Ootacamund, Nilgiri Hills ; alt. *ca.* 7,400 ft. Pond beyond cemetery.	23 specimens.
N 16	. Avalancho, Nilgiri Hills, S. India ; alt. 6,500 ft. 14.xi.32.	9 specimens.

[1] For full details regarding these species reference may be made to the paper by Annandale & Rao cited above, pp. 180 and 182 respectively.

[2] For reference to this form see Annandale & Rao, *loc. cit.*, p. 184 (1925).

Family PLANORBIDAE.

Genus **Indoplanorbis** Annandale & Prashad.

1921. *Indoplanorbis*, Annandale & Prashad, *Rec. Ind. Mus.* XXII, p. 578.
1923. *Indoplanorbis*, Rao, *Rec. Ind. Mus.* XXV, pp. 199-219, figs. 1-14.
1931. *Indoplanorbis*, Baker, *Proc. Zool. Soc. London*, p. 587.
1933. *Indoplanorbis*, Baker, *Journ. Morphol.* LV, pp. 1-9, pls. i, ii.

This genus was established by Annandale and the present author for the common large Planorbid of India, *Indoplanorbis exustus* (Deshayes), and the work of Rao and Baker on the anatomy of the species has fully upheld the separation of this species from the genus *Planorbis* Geoffroy.

Indoplanorbis exustus (Deshayes).

1834. *Planorbis exustus*, Deshayes, *Voyage Belanger Indes-Orient. Zool.*, p. 417. pl. i, figs. 11-13.
1921. *Planorbis exustus*, Prashad, *Rec. Ind. Mus.* XXII, p. 472.
1921. *Indoplanorbis exustus*, Annandale & Prashad, *id.*, p. 580.
1921. *Planorbis* (*Planorbis*) *exustus*, Germain, *Rec. Ind. Mus.* XXI, p. 26, pl. i, figs. 4-9; pl. iv, figs. 11, 17, 18, text-figs. 1-11, 13-16.

The great variation in the form of the shell of this highly variable species is discussed at length by Germain and Annandale and Prashad, while the anatomy has been described by Annandale and Prashad, Rao and Baker.

The Yale North India Expedition collected a single young shell of this species from St. P 2—Sohawa, Rawalpindi Dist. Punjab; alt. 1,734 ft.; 4.iii.32.

Genus **Gyraulus** Charpentier.

Gyraulus convexiusculus (Hutton).

1850. *Planorbis convexiusculus*, Hutton, *Journ. As. Soc. Bengal*, (2) XVIII, p. 657.
1919. *Gyraulus convexiusculus*, Annandale & Prashad, *Rec. Ind. Mus.* XVII, p. 52, fig. 7B.
1921. *Planorbis* (*Gyraulus*) *convexiusculus* and *P.* (*G.*) *saigonensis*, Germain, *Rec. Ind. Mus.* XXI, pp. 118, 119.

For detailed synonymy and description of the species reference may be made to the publications cited above. *G. convexiusculus* has a very wide range from " Lower Mesopotamia through Eastern Persia, Afghanistan and Northern India to Upper Burma, French Indo-China, China, Japan and the Malay Archipelago."

The Yale North India Expedition collected specimens of *G. convexiusculus* from the following localities :—

		Calcutta, Bengal; from an artificial fountain in Dalhousie Square. 30.x.32.	1 specimen.
P 2	.	Sohawa, Punjab; alt. 1,734 ft. 4.iii.32	9 specimens.
P 9	.	Khabakki Kabar, Punjab; alt. 2,481 ft. 12.iii.32.	1 specimen.

Gyraulus sp.

A young specimen of *Gyraulus* from St. N 15—Ootacamund, Nilgiri Hills, cannot be identified specifically.

PELECYPODA.

Genus **Pisidium** Pfeiffer.

Pisidium clarkeanum G. & H. Nevill.

1871. *Pisidium clarkeanum*, G. & H. Nevill, *Journ. As. Soc. Bengal*, XL, pl. ii, p. 9 ; pl. i, figs. 4, 4*a*-*d*.
1925. *Pisidium clarckeanum* (*sic*), Prashad, *Rec. Ind. Mus.* XXVII, p. 408, text-figs. 1-3, pl. vii, figs. 1, 2 ; pl. viii, figs. 1, 2.

For a detailed description of this species reference may be made to my paper cited above. *P. clarkeanum* is widely distributed in India and Burma.

The Yale North India Expedition collected 2 specimens of this species from St. N 2—Ootacamund, Nilgiri Hills ; alt. 7,400 ft. ; in a pond, on 10.xi.32.

STUDIES ON INDIAN ITONIDIDAE (CECIDOMYIDAE: DIPTERA)[1].

IV.—EIGHT NEW MIDGES.

By M. S. MANI, *M.A., Gallery Assistant, Zoological Survey of India, Indian Museum, Calcutta.*

The new species of midges described in this paper were mostly caught by Mons. Vitale Menasché's Entoray machine, which was recently tried in Calcutta. The catches contain several well known genera not previously recorded from India. I have also included the descriptions of two other species, one found swarming in the laboratories of the Imperial Agricultural Research Institute, New Delhi, and the other bred from the univalve galls of *Eagle marmelos*.

Lestremia calcuttaensis, sp. nov.

Female.—Length 1·75 mm. Orange. Palpus moderately setose; not counting the palpiger segments four; first segment rather stout, of a length about twice its diameter; second segment nearly equal in length to the first but more slender; third and fourth segments more slender, probably equal to each other and about twice the length of the second segment, differing in these respects from *L. indica* Kieff.[2] in which fourth palpal segment is twice the length of third. Length of terminal antennal segment about four times its diameter, with a more or less distinct constriction at basal fourth. Mesonotum dark brown. Anterior metatarsus about as long as the next three tarsal segments combined. Posterior tibia one and one fourth times the combined length of the first two tarsal segments. Claws simple, slender, slightly curved. Empodium very short. Terminal lamellae of ovipositor subquadrate, broadly rounded apically, length about one and one fourth the breadth, densely setose.

Holotype.—One female dissected on a slide in the collections of the Zoological Survey of India, Indian Museum, Calcutta, No. 1311/H6. Trapped by 'Entoray', Portland Park, Calcutta, 13-vii-1936.

This new species differs from the two other Indian species *L. indica* Kieff. and *L. ceylonica* Kieff.[3] mainly in the length of palpal segments, short, subquadrate terminal lamellae of ovipositor and much longer terminal antennal segment.

Micromyia indica, sp. nov.

Male.—Length about 1·5 mm. Palpus triarticulate; first segment much stouter and shorter than the rest, its thickness nearly equal to length; second more slender, twice the length of first, stouter apically

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[1] Part III of this series was published in *Rec. Ind. Mus.*, XXXVIII, pp. 193-197, (1936).

[2] Kieffer, *Rec. Ind. Mus.*, III, p. 29, (1909).

[3] Kieffer, *Spol. Zeyl.*, VIII, p. 29, (1912).

than basally; terminal segment nearly one and one third times the first, subfusiform and somewhat stout apically. Antennae somewhat less than one fifth the length of body, reduced apically; segments 10; third and fourth segments globose; fifth pyriform; sixth, seventh and eighth subcylindrical and with a distinct stem, about half the enlargement; ninth and tenth segments fused together. Mesonotum dark brownish to black. Scutellum brown, post scutellum lighter. Abdomen grey above and paler below and at the sides. Claws slender, long, sickle-shaped. Basal clasp segment of genitalia stout, short. Terminal clasp segment subfusiform, about one third the basal segment, apically armed with a short, slightly curved, sharp spine. Dorsal plate somewhat longer than basal clasp segment, apically bilobed and emarginate.

Holotype.--One male dissected on a slide No. 1312/H6.

Paratypes.—Several examples in spirit No. 1323/H6. Genitalia of one example is mounted on a slide.

Holotype in the collections of the Zoological Survey of India, Indian Museum, Calcutta and paratypes in the collections of the Zoological Survey and the Imperial Agricultural Research Institute, New Delhi.

Received from the Imperial Entomologist, New Delhi, with the label: 'Found swarming in laboratory compound. Coll. H. L. Bhatia, 28-ii-1937, I. A. R. I., New Delhi.'

Neolasioptera variipalpis, sp. nov.

Female.—Length of body varies between 1-2 mm. Bright reddish brown in colour. Palpus densely scaled, quadriarticulate; first segment short; second about twice longer and somewhat stouter; third more slender, either equal to or one and a half times the second, intermediate proportions are met with in a larger series of individuals; fourth either about twice the third or almost equal to (sometimes slightly longer than) the third; usually, however, the third and fourth are nearly equal and each about one and a half times the second. Occasionally the second, third and fourth are all equal. Antenna about half the length of body, segments 19, moderately hairy; fifth segment about three fourths the fourth, which latter is equal to third; terminal segment subglobose and slightly longer than the penultimate segment. Mesonotum dark reddish brown. Scutellum lighter than mesonotum. Wings about two and a half times as long as broad; third vein reaching costa at about basal two thirds. Claws long, slender, unidentate; tooth long, evenly curved; empodium much shorter than claws. Abdomen reddish brown. Ovipositor longer than body.

Holotype.—One female in spirit in the collections of the Zoological Survey of India, Indian Museum, Calcutta, No. 1313/H6.

Paratypes.—Several examples mounted in canada balsam in the collections of the Zoological Survey of India, Indian Museum, Calcutta, Nos. 1314-H/6.

Trapped by 'Entoray', Portland Park, Sahapur Yard, Gun Foundry, Cossipur and Sonarpur, Calcutta, 19-vi-1931 to July 1936.

This species resembles *N. crataevae* Mani[1] in colour of body, in the absence of scaly spots and markings on abdomen and costa, but differs in the fewer antennal segments and more slender claws. From *N. cephalandrae* Mani[2], which it resembles in the number of palpal segments, it is readily distinguished by the unspotted abdomen and wings, fewer antennal segments and relatively longer third vein, which unites with costa well beyond the basal half of wing. There is a considerable variation in the relative proportions of the third and fourth palpal segments, size of body and wings.

Asphondylia menaschei, sp. nov.[3]

Male.—Length about 2 mm. Reddish brown. Palpi triarticulate; first segment short, subquadrate; second segment of a length about two and a half times its diameter; third segment twice the second, with moderately dense, long and slender setae. Antennae reddish brown; third segment of a length about four to five times its diameter; fourth segment somewhat longer than third; fifth segment of a length about three and a half times its diameter. Mesonotum dark reddish brown. Genitalia moderately setose, dark brown; basal clasp segment stout; apical clasp segment very short, basally swollen very much and bidentate apically; the teeth short, black and greatly diverging. Claws as long as empodium.

Female.—Length about 2·5 mm. Reddish brown. Palpi triarticulate; first segment short, stout; second segment longer, somewhat stouter apically than basally, with long straight, stiff setae; third segment about twice the length of second, more slender, also with long stiff setae. Fifth segment of antennae of a length about five times its diameter and also about five sixths that of fourth. Mesonotum dark brown. Dorsal basal pouches of ovipositor moderately large. Claws as long as empodium.

Holotype.—One male dissected on a slide No. 1315/H6.

Allotype.—One female dissected on a slide No. 1316/H6.

Paratype.—One male dissected on a slide No. 1317/H6. In the collections of the Zoological Survey of India, Indian Museum, Calcutta. Trapped by 'Entoray', Portland Park, Calcutta, 13—17-vii-1936.

This species runs with *A. pongamiae* Felt in my key[4] to the Indian species of *Asphondylia*, agreeing with it in the terminal clasp segment of male genitalia but differing in the following characters: second palpal segment of a length slightly greater than twice its diameter; third palpal segment just twice the second, without stout but slender, moderately dense setae; fifth antennal segment of a length about four and half times its diameter.

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[1] Mani, *Rec. Ind. Mus.*, XXXVI, p. 399, (1934).

[2] Mani, *Ibid.*, p. 397.

[3] I have great pleasure in associating with this species the name of Mons. Vitale Menasché, the inventor of the Entoray, which trapped many gall midges.

[4] Mani, *Rec. Ind. Mus.*, XXXVI, pp. 408-409, (1934).

Hormomyia calcuttaensis, sp. nov.

Female.—Length 2·5 mm. Reddish brown. Palpi short, segments (including palpiger) three, the terminal segment somewhat longer than the rest and broadly rounded apically, the other segments are equal. Antennae about half the length of body; segments 14; third segment with a subcylindrical enlargement having a length about six times its diameter, stem about one sixth the length of the enlargement; fifth segment with a stem about four fifths the length of the segment, the enlargement of a length about four times its diameter; terminal segment sharply constricted in its apical third, forming a small oval part about half the length of the rest of the segment. Circumfili in two irregular whorls, the basal whorl is usually more irregular than the apical. Mesonotum dark reddish brown. Halteres long, the club much longer than the pedicel. Legs dark reddish brown. Claws simple, long, moderately stout, about three fourths the length of empodium. Abdomen reddish brown. Ovipositor long, terminal lamellae of a length about two and a half times its breadth, narrowly rounded apically.

Holotype.—One female dissected on a slide No. 1318/H6.

Paratypes.—Three females dissected on slides Nos. 1319/H6. One claw of one of the paratypes is abnormal, being forked to a short length.

In the collections of the Zoological Survey of India, Indian Museum, Calcutta. Trapped by 'Entoray', Portland Park, Calcutta, 4—9-vii-1936.

This species differs from the two other Indian species, *H. ischaemi* Felt[1] and *H. subaptera* Felt[2] in the antennal segments of female having only two instead of three whorls of circumfili, agreeing, however, in the number of antennal segments. The species is also further distinguished from *H. subaptera* by the wings being long and narrow as is usual in the genus *Hormomyia*.

Trishormomyia indica, sp. nov.

Female.—4 mm. long. Reddish. Palpi triarticulate (including the palpiger); second segment nearly equal to the basal but more slender; third segment slender and about twice the second. Antennae reddish brown; segments 15 (?); third segment distinctly constricted a little below the basal half, with a stem about one-fifth the subcylindrical enlargement, circumfili in two whorls; fourth segment about three fourths the length of third, its stem equal to that of third; fifth segment equal to fourth, with apparently only two whorls of circumfili, the basal whorl situated between the basal one fourth to basal half and the apical whorl near the tip of enlargement; sixth segment somewhat shorter than the fifth, its stem equal to that of the fifth. Mesonotum dark reddish brown. Scutellum lighter than mesonotum. Legs dark reddish brown. Claws stout, evenly curved, simple, somewhat shorter than or equal to the narrow, long empodium. Abdomen long,

[1] Felt. *Pusa Bull.*, No. 89, p. 46, (1920).
[2] Felt. *Mem. Dept. Agri. Ind. Ent. Ser.*, IX, p. 224, (1926).

deep reddish orange. Ovipositor long, terminal lobes moderately broad, short and oval.

Holotype.—One female dissected on a slide in the collections of the Zoological Survey of India, Indian Museum, Calcutta, No. 1320/H6. Trapped by 'Entoray', Portland Park, Calcutta, 14-vii-1936.

Orseoliella bengalensis, sp. nov.

Male.—Length about 2·75-3 mm. General colour dark brown. First palpal segment short, stout, subglobose; second segment more slender than others, about twice the length of first; third segment about one and one fourth the length of second; fourth nearly equal to third and broadly rounded apically; all segments moderately clothed with long setae. Antennal segments 14; fifth segment with a basal globose and an apical subcylindrical enlargement, the latter of a length about twice its diameter, more or less distinctly constricted in the middle; stems about one and a half to twice their diameters; apical subcylindrical enlargement of seventh and the following segments often constricted in the middle so that these segments appear trinodose. Mesonotum dark brown or dark reddish brown. Legs densely hairy. Claws moderately stout, evenly curved, much longer than the empodium. Abdomen yellowish to brownish, densely hairy. Genitalia densely hairy; dorsal plate heavily chitinised, deeply bilobed, lobes with rounded apical angles; ventral plate longer than dorsal plate, broadly rounded apically and somewhat narrowly emarginate at sides and subapically; basal clasp segment about twice as long as the ventral plate, with a large, obtuse, basal inner lobe; terminal clasp segment about half to three fourths the length of the basal clasp segment, moderately stout, slightly reduced and curved apically; style as long as or longer than ventral plate.

Holotype.—One male dissected on a slide in the collections of the Zoological Survey of India, Indian Museum, Calcutta, No. 1321/H6. Trapped by 'Entoray,' Portland Park, Calcutta, 20-vi-1936.

Paratypes.—Two examples on slides, Nos. 1324-25/H6.

This species has a general resemblance to *O. apludae* Felt[1] but is readily distinguished by the smaller size and free dorsal and ventral plates.

Cecidomyia dattai, sp. nov.[2]

Female.—Length 1·75-2 mm. General colour of body reddish brown. Palpi long, quadriarticulate, moderately setose; first segment short, quadrate; second segment over twice the length of first, somewhat stout; third segment nearly equal to second; fourth segment about one and a half times the length of third, somewhat slender. Antennae about half the length of body, with 14 cylindrical segments; third and

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[1] Felt, *Mem. Dept. Agric. Ind.*, Ent. Ser., VII, p. 8, (1920).

[2] *Cecidomyia* is employed here as a group name and not in the sense of *Itonida* Meig. *Vide* Felt, *Bull. N. Y. St. Mus.*, No. 257, p. 15, (1925); *Mem. Dept. Agric. Ind. Ent., Ser.*, VII, pp. 11, 27, (1920-1); X, pp. 2-3, (1927); Mani, *Rec. Ind. Mus.*, XXXVIII, p. 196, (1936). I associate with this species the name of my friend and colleague Mr. M. N. Datta, who reared the midge from its galls.

fourth segments fused together; fifth segment of a length about twice its diameter, stem about one fifth the length of segment; sixth to twelfth segments nearly equal; thirteenth segment somewhat shorter than twelfth, its stem nearly equal; terminal segment somewhat longer than thirteenth, with an apical prolongation about two seventh the total length. Mesonotum black, submedian lines scarlet, thickly haired. Wings hyaline, neither narrow nor broad, with three longitudinal veins, third vein uniting with costa beyond apex, fourth vein obsolete, fifth vein faint apically. Legs pale brown, densely hairy. Claws simple on all legs, not strongly curved, slightly shorter than empodium. Abdomen reddish brown. Ovipositor exserted, long; terminal lamellae ovate.

Holotype.—One female dissected on a slide in the collections of the Zoological Survey of India, Indian Museum, Calcutta. No. 1322/H6. Coll. M. S. Mani and M. N. Datta, Pulta Pumping Station, near Barrackpore, Calcutta, 5-vi-1936.

Notes.—This species produces the univalve galls on the leaflets of *Eagle marmelos* Corr. described in an earlier paper[1]. When mature, the larvae escape from the gall through the slit-like opening, wander about and drop to the ground. They enter the soil and pupate in cocoons at depths varying from half to two inches from the surface. The adults emerge from the ground in five to seven days. Before they burrow into the soil, the larvae are subject to attacks of enemies, the most common one being the Indian house sparrow. It picks off the larvae from the ground and thus destroys a large number of them.

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[1] Mani, *Rec. Ind. Mus.*, XXXVII, p. 444, (1935).

A REVISION OF THE INDIAN CHALCID WASPS OF THE SUB-FAMILY LEUCOSPIDINAE (PARASITIC HYMENOPTERA)[1].

By M. S. MANI, *M.A.*, *Gallery Assistant, Zoological Survey of India, Indian Museum, Calcutta.*

This paper is a resumé of my three years' work on the Indian Leucospidinae and represents the results of studies on practically all the material available in India. Fortunately unlike most other groups of the Chalcidoidea, the paratypes of several of the Indian species of Leucospidinae are available in this country. Through the courtesy of the authorities of the various institutions, I have been able to examine the valuable collections of the Zoological Survey of India, Indian Museum, Calcutta; Imperial Agricultural Research Institute, New Delhi and the Agricultural College and Research Institute, Coimbatore. Dr. T. V. Ramakrishna Ayyar, late Government Entomologist, Madras, also very generously placed at my disposal his extensive collections of Leucospids. As a result, except for Cameron's species, which have not been recognised since they were first described, I have examined all the species so far described from India. In two earlier papers (15, 16) I have described seven new species and recorded one well known species for the first time from India. I also recently described the male of *Leucospis bengalensis* Weld. which was described from females only. Of the sixteen species dealt with in this paper one is new to science; several of these species are redescribed, and notes on distribution and inter-relationships are added. A key to Indian species of *Leucospis* Fab. is also given. In the bibliography, the more important papers are arranged chronologically under authors, bringing the literature up to date.

I take this opportunity of recording my grateful thanks to Dr. Baini Prashad, Director, Zoological Survey of India, Indian Museum, Calcutta, for guidance, facilities for work and constant encouragement: to Dr. T. V. Ramakrishna Ayyar, late Government Entomologist, Madras, for his valuable suggestions and for donations and loan of valuable material; to Dr. Hem Singh Pruthi, Imperial Entomologist, Imperial Agricultural Research Institute, New Delhi and Mr. M. C. Cherian, Government Entomologist, Agricultural College and Research Institute, Coimbatore for loan of material for study.

LEUCOSPIDINAE.

The subfamily Leucospidinae is one of the easily recognised groups of the Chalcidoidea. Its members, mostly parasitic in the nest of bees, are found in all parts of the world, though the species are more numerous in the tropics than in the temperate regions. It comprises over two hundred species of the genera *Leucospis*, *Polistomorpha*, *Marres* and *Epexochlaenoides*.

Leucospids were recognised as a distinct group by Walker, though Dalla Torre (6) incorrectly gave the credit to Förster. Early workers

[1] This paper was prepared and submitted as a thesis for the M. A. degree in Research of the University of Madras in March, 1937.

like Walker, Haliday, Förster, etc., treated the group as a separate family. Howard (12) and Ashmead (1) recognised their close relationship to the Chalcidinae and placed them with the latter in the family Chalcididae. In 1890, Schletterer (19) comprehensively monographed the subfamily and recorded sixty species in three genera *Leucospis* (57 spp.), *Polistomorpha* (2 spp.) and *Marres* (1 sp.). In 1898, Dalla Torre (6) recorded eighty species from different parts of the world in his *Catalogus Hymenopterorum*; several of these species have, however, been regarded as synonyms by later workers. Cresson (5), Howard (12) and Ashmead (1) described several American species. Klug (14) made several additions to the European species. Kirby (13) also characterised the genera and described some species from England and other places. Ashmead (1) tabulated the genera in his monumental work on the classification of the Chalcid flies, and later Schmiedeknecht (20) monographed the subfamily in the *Genera Insectorum* series. Girault (11) studied the Australian forms and erected some new genera and species, most of which are not, however, valid. Weld (27) published a monographic revision of the Leucospidinae of the world, which is still a standard work of reference in the group.

Very little work has, however, been done on this group in India. *Leucospis guzeratensis* Westwood, the first species of the Leucospidinae to be recorded from India, was described by Westwood in 1839. Later on in 1906, Cameron (4) described two Indian species. In 1912, Enderlein (9) described one species from Ceylon. In 1922, Weld (27) described three Indian species, and in 1925, Brues (2) recorded one species from Malabar, South India. Several Indian species were recently described by me and altogether sixteen species have been recorded from India so far.

Leucospids are usually robust-bodied Chalcids, ranging in length from about 5 mm. to 15 mm. Pronotum is usually large. Black is the predominating colour, but most species are also conspicuously spotted or marked yellow, orange, red and sometimes white. Fore wings, while not in use, are longitudinally folded as in the Vespidae, which is an unusual feature among the Chalcids. Hind coxa and femur are very much swollen, the latter is also armed beneath with teeth. Hind tibia is strongly arched and always shorter than hind femur. Abdomen is elliptical or obovate in the lateral view; usually swollen behind the middle in the dorsal view; and sometimes subcompressed apically. Ovipositor is usually long, exserted, reflexed over the dorsum of abdomen, sometimes reaching forward to the scutellum of thorax. These characters readily serve to distinguish the Leucospidinae from the closely related Chalcidinae.

Genus **Polistomorpha** Westwood.

1839. *Polistomorpha*, Westwood, *Zeitschr. Entomol.*, I (2), p. 265.
1862. *Polistomorpha*, Walker, *Journ. Entomol.*, I, p. 22.
1874. *Polistomorpha*, Westwood, *Thesaur. Entomol. Oxon.*, p. 133.
1890. *Polistomorpha*, Schletterer, *Berlin. Entomol. Zeitschr.*, XXXV, p. 292.
1904. *Polistomorpha*, Ashmead, *Mem. Carnegie Mus.*, I (4), pp. 247, 402.
1906. *Polistomorpha*, Ducke, *Bull. Soc. Entomol. France*, pp. 163-166.
1909. *Polistomorpha*, Schmiedeknecht, *Gen. Ins.*, *fas.* 97, p. 14.
1922. *Polistomorpha*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 4.
1935. *Polistomorpha*, Mani, *Rec. Ind. Mus.*, XXXVII, pp. 242-243.

Polistomorpha was erected as a subgenus of *Leucospis* Fab. in 1839 by Westwood for his species *surinamensis* ; it was raised to a generic rank by Walker in 1860. Since then seven species have been described : *sphegoides* Walker[1] and *fasciata* Westwood[2] from the Amazon ; *nigrimaculata* Cameron[3] from Panama ; *nitidiventris* Ducke[4] from Europe ; and *indica* Mani and *paivai* Mani (*vide infra*) from India. In 1922, Weld transferred the Mexican species *bulbiventris* Cresson[5] from the genus *Leucospis* to *Polistomorpha.*

The genus has a wide range of distribution, though the species appear to be more numerous in the tropics than in the temperate regions. Of the two Indian species one is known from North and the other from South India.

The genus can be recognised by the following characters : Vertex not cornuted, posterior margin of head straight or nearly so ; third antennal segment as long as or longer than second ; pronotum equally broad both anteriorly and posteriorly ; scutellum normal, never heart-shaped ; central part of metathorax projecting ; hind coxae with or without a strong erect spur above ; abdomen spindle-shaped, never compressed, with or without median longitudinal furrow towards the posterior end, pointed apically ; ovipositor limited to the underside of abdomen.

Polistomorpha is readily distinguished from *Marres* Walk. by its non-cornuted head. From *Leucospis* Fab. and *Epexochlaenoides* Gir. it is separated by the fact that the ovipositor is not reflexed over the dorsum of abdomen but lies on the under side.

The relationship of the Indian species to the other known species is shown in the key below, which is modified from Ducke (7).

Key to species.

I. Hind coxa unspurred above ; usually small species
- A. Hind femur with over 10 teeth, first tooth large, rest small ; carina on pronotum faint . . *P. bulbiventris* (Cresson).
- B. Hind femur with only 5 teeth ; first tooth small, second, third and fourth long, fifth large and tridenticulate ; single well developed carina on pronotum . . . . *P. indica* Mani.

II. Hind coxa spurred above ; or at least with a carinate upper edge ; usually large species
- A. Hind femur with 8 teeth, first larger than the rest ; two transverse carinae on pronotum . *P. paivai* Mani.
- B. Hind femur with only 6-7 teeth ; first tooth larger than the rest
  1. Body black . . . . . *P. sphegoides* Walker.
  2. Body testaceous
     - *a.* Fourth tergite of abdomen shiny, with a coarse punctation ; first tooth of hind femur triangular *P. nitidiventris* Ducke.

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[1] Walker, *Journ. Entomol. London*, I, p. 22, (1862).
[2] Westwood, *Thesaur. Entomol. Oxon.*, p. 133, (1874).
[3] Cameron, *Trans. Amer. Entomol. Soc.*, XXX, p. 96, (1904).
[4] Ducke, *Bull. Soc. Entomol. France*, p. 165, (1906).
[5] Cresson, *Trans. Amer. Entomol. Soc.*, IV, p. 29, (1872).

b. Fourth tergite of abdomen somewhat opaque, with a fine punctation; first tooth of hind femur very long and sharp . . . *P. fasciata* Westwood.

c. Fourth tergite of abdomen opaque, finely and densely punctate; first tooth of hind femur large and triangular . . . *P. surinamensis* Westwood.

Polistomorpha indica Mani.

1935. *Polistomorpha indica*, Mani, *Rec. Ind. Mus.*, XXXVII, pp. 243-244, fig. 1.
1936. *Polistomorpha indica*, Mani, *Rec. Ind. Mus.*, XXXVIII, p. 338.

This species was originally described from a specimen from Yercaud, South India, in a collection of Chalcids received from Dr. T. V. Ramakrishna Ayyar. The female is easily recognised by the presence of a single well developed transverse carina on the pronotum posteriorly parallel to its hind margin, with two transverse elliptic yellow spots at its ends. There is also a somewhat broad, transverse, complete yellowish band anteriorly on the pronotum. Dorsum of abdomen has three transverse, yellow bands. Hind femur has four simple and one (fifth) compound teeth. The upper edge of hind femur is bordered by a broad yellow band on the outer side; there is also a longitudinal, oblong, yellow spot on the outer side just above the third, fourth and first part of the fifth teeth. The male is unknown.

Polistomorpha paivai Mani.

1936. *Polistomorpha paivai*, Mani, *Rec. Ind. Mus.*, XXXVIII, p. 338.

This species is closely related to *P. indica* Mani, from which, however, it is easily distinguished by the following characters: There are two transverse carinae on pronotum parallel to its hind margin, which is also carinate. Hind femur has eight teeth, the last one being compound. There is a single yellow, transverse band on the carina on pronotum. Hind femur has only a single irregularly-shaped yellow spot outside at the base and not extending to apex. There are only two transverse yellow bands on the dorsum of abdomen.

No females of the species have been discovered so far.

Described from a specimen in the collections of the Zoological Survey of India, Indian Museum, Calcutta, bearing the label: "Coll. Paiva, Katihar, Purneah Dist., 4-viii-1907"

Genus **Leucospis** Fabricius.

1775. *Leucospis*, Fabricius, *Syst. Entomol.*, I, p. 361.
1874. *Leucospis*, Westwood, *Thesaur. Entomol. Oxon.*, p. 135.
1890. *Leucospis*, Schletterer, *Berlin. Entomol. Zeitschr.*, XXXV, p. 141.
1894. *Exochlaenus*, Shipp, *Entomologist*, XXVII, p. 16.
1904. *Leucospis*, Ashmead, *Mem. Carnegie Mus.*, I (4), p. 247.
1909. *Leucospis*, Schmiedeknecht, *Gen. Ins.*, *fas.* 97, p. 14.
1922. *Leucospis*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, pp. 4-35.
1935. *Leucospis*, Masi, *Boll. Soc. Entomol. Italina*, LXVII, pp. 36-43.
1935. *Leucospis*, Mani, *Rec. Ind. Mus.*, XXXVII, p. 244.

This genus was erected by Fabricius in 1775 and was comperhensively dealt with by Schletterer in his monograph on the genera *Leucospis*,

Polistomorpha and *Marres*. In 1894, Shipp transferred the species *L. anthioides* Westw. to his new genus *Exochlaenus*; and this was accepted by Ashmead and Schmiedeknecht. In his recent monograph on the Leucospidinae, Weld has reunited under *Leucospis* all the species referred to *Exochlaenus*, which according to him is not distinct from the former. From a study of the various Indian species Dr. Ramakrishna Ayyar and I agree with Weld's view.

Body more or less robust. Head triangular in the front view; vertex not cornuted; cheek long, not converging below; posterior margin of head curved inwards; maxillary palpi quadriarticulate; labial palpi triarticulate; mandibles short and broad. Eyes large. Antennae slightly thickened apically, with 12 segments. Pronotum nearly of equal width both anteriorly and posteriorly. Mesonotum longer than pronotum in the median line, at least never shorter. Scutellum never heart-shaped. Metanotum either rounded or with a spinous process apically. Hind coxa with or without a spur above. Hind femur with less than twenty teeth, which are never minute or comb-like. Fore tibia with one spur; hind tibia with two spurs. Abdomen elliptic or obovate in the lateral view, more or less compressed sub-apically; the apex rounded. Ovipositor reflexed over the dorsum of abdomen.

Abdomen is composed of eight tergites, not counting the median segment (propodium), but several of the tergites are more or less telescoped and hidden from view. First tergite is narrow and ring-like, forming a short constricted portion between the median segment and the second (the *first* apparent) tergite. Second tergite is well developed and in some species is longer in the median line than the others. Third and fourth tergites are usually telescoped together but the former is distinctly visible in the female of *L. indiensis* Weld. Fourth and fifth are together shorter than the second tergite. Sixth tergite is usually the largest Seventh is small and is easily recognised by its conspicuous spiracle. Eighth varies according to sex; in female it consists of two halves, enclosing the ovipositor. In male several of the tergites are more or less fused together.

Species of *Leucospis* are parasitic in the nests of bees and attack *Chalicodoma*, *Megachile*, *Anthidium* and *Osmia*. No work has been done so far on the biology of any Indian species.

Leucospis guzeratensis Westwood[1], described in 1839, was the first species of *Leucospis* recorded from India. Eleven more species and one variety have since been described from different parts of India: *nursei* Cameron[2] and *quettaensis* Cameron[2] from Quetta; *viridissima* Enderlein[3] from Ceylon; *malabarensis* Brues[4] from Malabar, South India; *indiensis* Weld[5] from Coimbatore; *bengalensis* Weld[6] from Pusa; *meenakshiae* Mani[7] from Tanjore; *bombayensis* Mani[8] from Bombay;

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[1] Westwood, *Zeitschr. Entomol.*, I (2), p. 253, (1839).
[2] Cameron, *Journ. Bombay Nat. Hist. Soc.*, XVII, pp. 91-92, (1906).
[3] Enderlein, *Entomol. Mitteil.*, I (5), p. 144, (1912).
[4] Brues, *Psyche*, XXXII, p. 27, (1925).
[5] Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 20, (1922).
[6] Weld, *ibid.*, p. 32.
[7] Mani, *Rec. Ind. Mus.*, XXXVII, p. 244, (1935).
[8] Mani, *ibid.*, p. 246.

ramakrishnai Mani[1] from Pusa and *assamensis* Mani[2] from Assam. *L. ornatifrons* Weld,[3] originally described from the Philippines also occurs in South India. *L. bengalensis* var. *mackenziei* Mani[2] is known from Chapra, Bihar.

A key to all the species so far described from India is given below. Cameron's two species *nursei* and *quettaensis* are placed in the key from Cameron's descriptions only. All the species so far described from India have one or two transverse carinae on pronotum parallel to its hind margin, which latter is also sometimes carinate. The following nine species have a single carina on pronotum: *L. indiensis* Weld, *L. darjilingensis*, sp. nov., *L. ornatifrons* Weld, *L. malabarensis* Brues, *L. viridissima* Enderlein, *L. meenakshiae* Mani, *L. nursei* Cameron and *L. quettaensis* Cameron.

Key to species.

1. Pronotum with only *one* transverse carina parallel to its hind margin	2.
Pronotum with *two* transverse carinae parallel to its hind margin	11.
2. Ovipositor reflexed over the dorsum of abdomen but not reaching the hind margin of the second (first apparent) tergite of abdomen	3.
Ovipositor reflexed over the dorsum of abdomen, reaching forward beyond the hind margin of the second tergite of abdomen	4.
3. Ovipositor nearly touches the anterior margin of the sixth tergite; pronotal carina faint; hind coxa with a sharp angle above; metanotum rounded apically	*L. indiensis* Weld.
4. Metanotum simple, rounded posteriorly . . .	5.
Metanotum produced or spined (bidentate) . .	10.
5. Ovipositor reaches forward a little of the middle of the second tergite	*L. darjilingensis*, sp. nov.
Ovipositor reaches forward of front margin of the second tergite	6.
6. Ovipositor reaches metanotum, small species . .	*L. ornatifrons* Weld.
Ovipositor reaches forward beyond metanotum . .	7.
7. Ovipositor reaches forward beyond the apex of scutellum	*L. malabarensis* Brues.
Ovipositor reaches apex of scutellum . . .	8.
8. Pronotum reticulately sculptured, length of female 12·5 mm., colour metallic	*L. viridissima* Enderlein.
Pronotum umbilicately or rugosely punctate . .	9.
9. Spots and markings mostly reddish in colour; length of female 9·25 mm.; pedicel of antenna about half the length of the first funicular segment; fourth funicular about three fourths length of third; mesopleura with a large sub-triangular spot . . .	*L. meenakshiae* Mani.
Spots and markings gamboge yellow: length of female 10 mm.; pedicel of antenna less than half the length of the first funicular segment; fourth funicular equal to third; mesopleura unspotted . . .	*L. assamensis* Mani.

[1] Mani, *Rec. Ind. Mus.*, XXXVII, p. 248, (1935).
[2] Mani, *Rec. Ind. Mus.*, XXXVIII, p. 338, (1936).
[3] Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 22, (1922).

10. Hind femur with 8 teeth	*L. nursei* Cameron.
Hind femur with 10 teeth	*L. quettaensis* Cameron.
11. Ovipositor does not reach the middle of second tergite of abdomen	12.
Ovipositor reaches forward of the middle of the second tergite of abdomen	13.
12. Length of female 11-12 mm. ; propodium with distinct median keel and prominent lateral carinae ; hind femur with 10 teeth	*L. bengalensis* Weld.
Length of female 9·5 mm. ; propodium without median keel and lateral carinae ; hind femur with 11 teeth .	*L. bengalensis* var. *mackenziei* Mani.
13. Sixth tergite of abdomen most usually with spots or markings, rarely without	14.
Sixth tergite of abdomen always without spots or markings	*L. guzeratensis* Westwood.
14. Length of female 5·5 mm. ; with numerous white spots and markings	*L. bombayensis* Mani.
Length of female 10 mm. ; with a few pale yellow or yellow spots ; sixth tergite is rarely unspotted ; hind femur always unspotted ; pubescence of abdomen as in *L. guzeratensis* Weld	*L. ramakrishnai* Mani.

Leucospis indiensis Weld.

1922. *Leucospis indiensis*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 20, pl. iii, fig. 19.
1935. *Leucospis indiensis*, Masi, *Boll. Soc. Entomol. Italina*, LXVII, (3), p. 41.
1936. *Leucospis indiensis*, Mani, *Rec. Ind. Mus.*, XXXVIII, p. 339.

This species was originally described by Weld from a female collected by Dr. Ramakrishna Ayyar at Coimbatore, South India. I recently recorded this species from the Sunderbans, Bengal. Masi has recently described the male.

This species is easily recognised by the single, faint, transverse carina on pronotum, ovipositor reaching only the anterior margin of the sixth tergite of abdomen, sharply angled hind coxa and apically rounded metanotum. From the closely related *L. ornatifrons* Weld this species is readily distinguished by its much larger size, ovipositor not reaching metanotum and by colouration.

Female.—Length 10·5-11·25 mm. Head somewhat wider than the anterior margin of pronotum, densely clothed with silvery white pubescence ; finely, closely and rugosely punctate. Inner border of eyes more pronouncedly sinuate than in *L. guzeratensis*. Ocelli reddish brown, the front one placed outside the antennal fovea. Vertex more or less striated on the outer side of lateral ocelli. Occipital carina, though distinct between eyes, disappears behind them. Pronotum with long, faint, transverse carina, parallel to its hind margin and covered by a white, pale yellow or yellow band ; the anterior white or yellow band on pronotum is long, and follows its front margin ; it is separated from the front margin of pronotum by a distance about twice that between the posterior band and posterior margin of pronotum ; punctation rugose. Scutellum umbilicately punctate. Metanotum rounded apically. Spiracular areas of propodium densely clothed with long, silvery white pubescence. Hind coxa with a sharply angled upper margin, where there is no punctation.

Abdomen reddish towards the base; in the dorsal view narrowed just in front of and swollen behind middle, compressed apically; in the lateral view broadest in the middle, depressed apically. Ovipositor very nearly touches the anterior margin of sixth tergite; its groove is rather deep.

General colour of body black; spotted or marked white, pale yellow or yellow as follows: Narrow, long transverse bands anteriorly and posteriorly on pronotum; the posterior band shorter than the anterior; a semi-circular spot on the smooth polished postero-median area of propodium; two small subtriangular spots postero-laterally on second tergite; one narrow band posteriorly on sixth tergite; fore femur apically above; outer basal half of fore tibia; base and apex of middle tibia; there is a broad irregular band near basal tooth of hind femur and extends across front and upper margin to apex; outside of hind tibia apically.

Leucospis darjilingensis, sp. nov.

This new species is easily distinguished from the closely related *L. ornatifrons* Weld, *L. meenakshiae* Mani and *L. assamensis* Mani by its relatively shorter ovipositor and spotted eighth tergite of abdomen.

Female.—Length 8 mm. Head somewhat wider than the anterior width of pronotum; not narrow in dorsal view; frons rugosely sculptured, moderately densely pubescent; line from front ocellus to lower border of clypeus nearly equal to the greatest distance between eyes; outer edges of scapal furrows faintly carinate; eyes very slightly sinuate; front ocellus outside the scapal furrows; postocellar space nearly equal to the ocellocular; occipital carina faint; striations on the outer side of lateral ocellus rather prominent. Pronotum about three fourths the length of mesonotum in the median line, with one faint transverse carina parallel to its hind margin, which is also rather faintly carinate. Pro- and mesonotums closely rugosely punctate. Front half of thorax bent downwards. Scutellum broadly rounded apically. Propodium slightly longer than the metanotum in the median line, without a median keel but with lateral carinae and hairy spiracular areas. Hind coxa closely and minutely punctate. Hind femur about twice as long as wide, closely setigerous, punctate; teeth five; first tooth small; second long and blunt; third and fourth longer and sharper than second; fifth tridenticulate. Fore wings faintly clouded apically.

Seen from above, abdomen has a length about twice its greatest width; second tergite longest, with a single median longitudinal furrow for ovipositor; third and fourth tergites covered. Seen from the side, abdomen is straight along the dorsum, narrow basally, wide apically; finely punctate, pubescence more dense apically than elsewhere. Ovipositor reaches the basal one fourth of second tergite.

Body spotted or marked yellowish brown as follows: A broad band, irregular in width, which begins near the front, where it is broadest, extends across upper margin to apex; a stripe posteriorly from the base to apex of hind tibia on the outer side; scape of antennae below; and two oblong, oblique stripes on eighth tergite. Other spots and markings are brick red as follows: Frons between eyes and antennal foveae,

broader below than above; spur between the antennal foveae (scapal furrows); broad, curved, transverse band anteriorly on pronotum; a darker band on the pronotal carina posteriorly; a curved band at posterior margin of scutellum; elongated spot on metapleura; short stripes above and below on fore femur; fore tibia in front; fore tarsus; middle tibia in front; middle tarsus; hind coxa at base above and at apex below; hind tarsus; pair of oblique bands on second tergite, beginning antero-medially and running latero-posteriorly, narrow at base and broad apically; narrow transverse band on fifth tergite; broad transverse band posteriorly on sixth tergite. Propodium unspotted.

Holotype.—One pinned female, Mus. Coll., Darjiling, Himalayas, 1000-3000 ft., May, 1912. Reg. No. 1571/H3. In the collections of the Zoological Survey of India, Indian Museum, Calcutta.

Leucospis ornatifrons Weld.

1922. *Leucospis ornatifrons*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 22.
1935. *Leucospis ornatifrons*, Masi, *Boll. Soc. Entomol. Italina*, LXVII, p. 41.
1935. *Leucospis ornatifrons*, Mani, *Rec. Ind. Mus.*, XXXVII, p. 245.

This species was described by Weld from Manila, Philippine Islands and was later recorded by Masi from Borneo and other places. It is represented by one specimen in a collection of Leucospids from South India received about three years ago from Dr. Ramakrishna Ayyar, bearing the label " Coll. T. V. R., Salem, 2-8.xii.1914 ".

This is a small species (length about 6-7 mm.) with a single carina on pronotum, in which respect it resembles *L. darjilingensis*, but it is easily distinguished from the latter species by its rather long ovipositor reaching metanotum. Face has a conspicuous yellowish marking. Sixth tergite of abdomen and pleurae are spotted. Median segment is unspotted.

Leucospis malabarensis Brues.

1925. *Leucospis malabarensis*, Brues, *Psyche*, XXXII, p. 27.

This is a medium-sized species easily recognised by the single pronotal carina, carinate posterior margin of pronotum, ovipositor reaching forward of the apex of scutellum, apically rounded metanotum and yellow and ferruginous markings. Frons minutely and reticulately sculptured. Outer edges of scapal furrows are distinctly carinate. Basal tooth of hind femur is small, the next three long and widely separated, fifth shorter, sixth compound. Pleurae and spiracular areas of propodium have long, villous, silvery white pubescence.

According to Brues this species differs from *L. nursei* Cam. and *L. quettaensis* Cam. in the apically rounded metanotum. The species is known from Malabar, South India.

Leucospis viridissima Enderlein.

1912. *Leucospis viridissima*, Enderlein, *Entomol. Mitteil.*, I, p. 144.

This Ceylonese species is distinguished from all the other Indian species so far described by its metallic colouration. From *L. malabarensis* it is further distinguished by its much larger size (length 12·5

mm.) and shorter ovipositor. Pronotum reticulately sculptured; mesonotum and scutellum are also similarly sculptured. Head, thorax, abdomen, legs, antennal scapes and sheath of ovipositor are deep metallic green; dorsum of thorax and anterior part of abdomen are not, however, metallic.

Leucospis meenakshiae Mani.

1935. *Leucospis meenakshiae*, Mani, *Rec. Ind. Mus.*, XXXVII, pp. 244-246, fig. 2.

This species very closely resembles *L. ornatifrons* Weld, from which, however, it is easily distinguished by the relatively longer ovipositor, clouded fore wings and other characters. Spots and markings are usually more reddish or orange than yellow.

Female.—Head transverse, slightly wider than the anterior margin of pronotum; frons rugosely punctate, shortly pubescent; outer edges of scapal furrows distinctly carinate; there are two faint depressions a little below the lower level of scapal furrows; line from the front ocellus to the lower level of clypeus about equal to the greatest distance between eyes; malar space about one fourth the length of eyes; eyes slightly sinuate; front ocellus at the apex of the antennal foveae; postocellar space about one half the ocellocular; occipital carina prominent in the median line and faint behind the eyes; occiput is faintly striate outside the eyes. Propodium almost equal in length to metanotum in the median line, nearly twice laterally, without median keel but with prominent lateral carinae and hairy spiracular areas. Hind coxa closely punctate.

Holotype re-examined. Coll. Miss Meenakshi, Tanjore, 29-xi-1932. Reg. No. 893/H3. In the collections of the Zoological Survey of India, Indian Museum, Calcutta.

Leucospis assamensis Mani.

1936. *Leucospis assamensis*, Mani, *Rec. Ind. Mus.*, XXXVIII, p. 339.

This species agrees with *L. meenakshiae* Mani in all essential characters but differs in the following:—

Female.—Head densely clothed with silvery white pubescence. All spots and markings on body are wholly gamboge yellow. Pedicel of antenna somewhat less than half the length of first funicular segment. Hind femur glossy, more finely and closely punctate than hind coxa; third tooth stouter than second. Spot on face between eyes and scapal furrows relatively larger and contiguous with eye and borders of furrows. Anterior band on pronotum not dilated at ends. Mid-dorsum of mesonotum unspotted. Mesopleura usually unspotted. There is sometimes a minute subelliptic spot on either side of eighth tergite of abdomen. Metanotum usually rounded apically, sometimes slightly pointed. Lateral carina on propodium faint. Fore wings hyaline basally and faintly clouded antero-apically.

Holotype re-examined. Coll. S. E. Peal, Sibsagar, Assam, Reg. No. 930/H3. In the collections of the Zoological Survey of India, Indian Museum, Calcutta.

Leucospis nursei Cameron.

1906. *Leucospis nursei*, Cameron, *Journ. Bombay Nat. Hist. Soc.*, XVII, p. 92.

This species was described by Cameron from Quetta, and has not since been recognised, though Brues (2) discusses its relationship to *L. malabarensis* Brues in the light of Cameron's description.

Leucospis quettaensis Cameron.

1906. *Leucospis quettaensis*, Cameron, *Journ. Bombay Nat. Hist. Soc.*, XVII, p. 91.

This species, described by Cameron from Quetta, has not also been since recognised. According to Cameron it differs from *L. nursei* Cameron mainly in its smaller size.

Leucospis bengalensis Weld.

1922. *Leucospis bengalensis*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 32.
1936. *Leucospis bengalensis*, Mani, *Rec. Ind. Mus.*, XXXVIII, p. 339.

This species has two pronotal carinae. It was originally described by Weld from females collected by Dr. Ramakrishna Ayyar at Pusa. I recently described the male from a specimen in the material received from Dr. Hem Singh Pruthi, Imperial Entomologist, New Delhi.

The female ranges in length from about 11 to 12 mm. Occipital carina is not very high. In addition to the two usual carinae, the hind margin of pronotum is also carinate. Fore wings are dark and have a purplish iridescence. Hind coxa is unspurred above. Propodium has a distinct median keel and prominent lateral carinae. Ovipositor reaches the basal fourth of second tergite ; fovea of ovipositor reaches the base of abdomen.

Male.—Length 10 mm. Head narrower than the anterior margin of pronotum ; coarsely rugosely sculptured ; covered with moderately dense, short, silvery white pubescence ; line from front ocellus to the lower edge of clypeus about one and one third the greatest distance between eyes ; clypeus sinuate at lower edge, with minute teeth in the median line ; eyes very slightly sinuate ; post-ocellar space somewhat less than ocellocular ; third funicular segment of antennae somewhat shorter than fourth. Pronotum transversely rugosely punctate ; almost equal in length to mesonotum in the median line ; with two transverse carinae parallel to its hind margin, which is also carinate, anterior carina short, posterior long. Mesonotum somewhat more coarsely sculptured than pronotum. Scutellum coarsely umbilicately punctate. Propodium about twice the length of metanotum in the median line, rugosely sculptured, median keel absent, lateral carinae prominent, spiracular areas hairy. Hind coxa closely punctate. Hind femur finely, closely and setigerously punctate, twice as long as wide, with ten teeth beneath ; front tooth broad and blunt ; second small, next longer, the last four gradually growing smaller and semifused.

Abdomen almost equal to the rest of body in length, seen from above narrow and constricted in the second tergite ; swollen behind ; sixth tergite largest and covers three fourths the abdomen. Wings brown, with a slight iridescence. Scape yellowish white beneath nearly the

whole of its length. Hind coxa unspotted. A narrow, transverse yellowish band at basal third and two large napiform markings laterally at basal two thirds on sixth tergite. A small spot on anterior carina on pronotum in the median line.

Allotype re-examined. Coll. F. M. Howlett, Pusa. 4-iv-1911.

Leucospis bengalensis var. **mackenziei** Mani.

1936. *Leucospis bengalensis*, var. *mackenziei*, Mani, *Rec. Ind. Mus.*, XXXVIII, p. 339.

This variety of *L. bengalensis* Weld is easily distinguished from the typical form by the following characters :—

Female.—Length 9·5 mm. Markings on anterior carina on pronotum relatively longer in some specimens. Propodium without a median keel or lateral carina. Hind femur with 11 teeth, basal tooth broad and blunt, second and third teeth minute, fourth to seventh large, eighth to eleventh small, semifused. Face relatively more densely clothed with longer silvery white hairs.

Holotype re-examined. Coll. Mackenzie, Chapra, Bihar. Originally described from a specimen received from Dr. Hem Singh Pruthi, Imperial Entomologist, New Delhi.

Leucospis guzeratensis Westwood.

1787. *Leucospis petiolata*, Fabricius, *Mantiss. Ins.*, I, p. 285.
1793. *Leucospis petiolata*, Fabricius, *Syst. Entomol.*, II, p. 247.
1798. *Leucospis atra*, Fabricius, *Syst. Entomol.*, Suppl., p. 259.
1839. *Leucospis atra*, Westwood, *Zeitschr. Entomol.*, I, (2), p. 252.
1839. *Leucospis petiolata*, Westwood, *Zeitschr. Entomol.*, I, (2), p. 253.
1839. *Leucospis guzeratensis*, Westwood, *Zeitschr. Entomol.*, I, (2), p. 253.
1890. *Leucospis guzeratensis*, Schletterer, *Berlin. Entomol. Zeitschr.*, XXXV, p. 224.
1898. *Leucospis guzeratensis*, Dalla Torre, *Cat. Hymen.*, V, p. 411.
1909. *Leucospis guzeratensis*, Schmiedeknecht, *Gen. Ins.*, *fas.*, 97, p. 16.
1922. *Leucospis guzeratensis*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 33.

This species is easily recognised by the two transverse carinae on pronotum, relatively long ovipositor reaching forward of the middle of the second tergite, single spot on pronotum and unspotted sixth tergite. It exhibits a great variation in size, the length ranging between 9-12 mm. It was originally described from Gujerat, Bombay Presidency and Tranquebar, Madras Presidency. It is represented by one female in a small collection of Leucospids (taken at Coimbatore) received from Mr. M. C. Cherian, Government Entomologist, Coimbatore. Weld has also recorded the species from the same place.

From *L. bengalensis* Weld this species is distinguished by its relatively longer ovipositor ; large, sharp, basal tooth and blunt, small apical teeth of hind femur ; basally and posteriorly semi-hyaline fore wings ; absence of median keel on propodium ; and an irregular transverse band on anterior pronotal carina.

Leucospis bombayensis Mani.

1935. *Leucospis bombayensis*, Mani, *Rec. Ind. Mus.*, XXXVII, p. 246.

This species resembles *L. guzeratensis* Westw. in its two pronotal carinae and long ovipositor but it is easily distinguished from it by its

smaller size, spotted sixth tergite and non-iridescent fore wings. It bears a superficial resemblance to *L. ornatifrons* Weld and *L. meenakshiae* Mani, from both of which it is easily separated by the presence of two carinae on pronotum.

Female.—Head somewhat wider than the anterior margin of pronotum, densely clothed with silvery white hairs; line from the front ocellus to the lower border of clypeus about equal to inter-ocular space; eyes very slightly sinuate; postocular space twice the ocellocular; malar space about one fourth the length of eye; occipital carina wanting; striations on the outer side of lateral ocelli rather faint. Pronotum rather bent downwards, with two transverse carinae parallel to its hind margin, which is also carinate. Propodium about twice the length of metanotum in the median line, without a median keel but with distinct lateral carinae and hairy spiracular areas. Scutellum obtusely rounded apically.

Holotype re-examined. Coll. R. B. S. Sewell and H. S. Rao, Satara, Bombay, 24-iii-1932. Reg. No. 894/H3. In the collections of the Zoological Survey of India, Indian Museum, Calcutta.

Leucospis ramakrishnai Mani.

1935. *Leucospis ramakrishnai*, Mani, *Rec. Ind. Mus.*, XXXVII, p. 248.

This species is very closely related to *L. guzeratensis* Westw. and *L. bengalensis* Weld. From the former it is easily distinguished by its unspotted hind femur, usually spotted sixth tergite and two small spots medially on anterior carina of pronotum. From the latter it is distinguished by its relatively longer ovipositor.

The species was originally described from Pusa. In a small collection of Leucospids recently received from Mr. M. C. Cherian, Government Entomologist, Coimbatore, it is represented by one female bearing the label: " Pudur. Visiting flowers of Mango ". This is the first record of the species from South India.

Female.—Head almost as wide as anterior margin of pronotum; face rather densely clothed with long, silvery white hairs; line from the front ocellus to the lower edge of clypeus about one and one seventh of the inter-ocular space; malar space about one third the length of eye; clypeus truncate at the lower edge; eye distinctly sinuate; spur between scapal furrows carinate; occipital carina rather prominent between the two lateral ocelli, wanting beyond; postocellar space about one and one fourth the ocellocular. Lateral margin of pronotum carinate. Scutellum obtusely rounded apically; transversely and deeply punctate along the posterior margin. Propodium slightly longer than the metanotum in the median line, without median keel but with prominent lateral carinae and hairy spiracular areas. Fifth tergite of abdomen about one and one fourth times the fourth tergite along the median line. Ovipositor reaching a little forward of the basal fourth of second tergite. Second tergite is more densely hairy and sculptured than sixth tergite.

Holotype re-examined. Coll. Ramakrishna, Pusa, 23-v-1906. Reg. No. 885/H3. In the collections of the Zoological Survey of India, Indian Museum, Calcutta.

Genus **Epexochlaenoides** Girault.

1915. *Epexochlaenoides*, Girault, *Mem. Queensland Mus.*, IV, p. 357.
1922. *Epexochlaenoides*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 35.

This genus bears a general resemblance to *Leucospis* but differs in the comb-like teething following the large basal tooth of hind femur (teeth over twenty in number); pear-shaped, apically subglobose abdomen; and large sixth tergite. Only two species of this genus are known: *E. bicinctus* Gir. from Australia and *E. pyriformis* Weld from India.

Epexochlaenoides pyriformis Weld.

1922. *Epexochlaenoides pyriformis*, Weld, *Proc. U. S. N. Mus.*, LXI, art. 6, p. 35.
1936. *Epexochlaenoides pyriformis*, Mani, *Rec. Ind. Mus.*, XXXVIII, p. 338.

This species was originally described by Weld from Pusa and I recently recorded it from Bombay. In a collection of Chalcids received for identification from Dr. Hem Singh Pruthi, Imperial Entomologist, New Delhi, this species is represented by a series of specimens labelled as parasitising *Rhynchium nitidulum*.

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ACANTHOCEPHALA FROM INDIA.

Description of the Male of *Eosentis rigidus* Van Cleave occurring in the Intestine of *Scizothorax zarudnyi* from Seistan.

By M. N. Datta, *M.Sc., Zoological Survey of India, Indian Museum, Calcutta.*

Van Cleave[1] erected the genus *Eosentis* from a single female specimen and no male of *E. rigidus* has ever been described so far. Recently, however, I found both males and females of this species in the intestine of *Scizothorax zarudnyi* collected by Dr. N. Annandale from Seistan. Thirty five specimens, of which twelve are males, were taken out of the small intestine of one fish. As the specimens were rather stiff owing to the action of preservatives for many years, they were softened in a mixture of alcohol and glycerine, spread out and pressed between two slides, stained and mounted in balsam. The identification was confirmed by examination of the holotype in the collections of the Indian Museum.

According to Van Cleave *Eosentis* is distinguished from the other closely related genera by the difference in the number of cuticular nuclei, though the exact number is not mentioned by him. The nuclei are quite distinctly seen in the holotype; there are 8-9 cuticular nuclei in the mid-dorsal and 1-2 in the mid-ventral lines. This number is found constant in a large series of specimens and may, therefore, be taken as the distinguishing character of the genus *Eosentis*. In this respect *Eosentis* differs from the closely related *Neoechinorhynchus*, in which there are only 4-5 cuticular nuclei in the mid-dorsal and 1-2 in the mid-ventral lines. Another point in which this genus differs from *Neoechinorhynchus* is the number of the nuclei in the lemnisci; in *Eosentis* there are always 3 in both, while in *Neoechinorhynchus* there are 2 in one and 1 in the other. On the basis of these characters I have placed two of my recent species *devdevi* and *yalei*[2] in *Eosentis*. There are 6-8 nuclei in the prostatic gland in *Eosentis*.

The proboscis is short and globular with 3 circlets of 6 hooks each. The hooks of the anterior circlet are nearly twice the length of those of the middle and basal circlets. The proboscis sheath is single-walled, thick and muscular, with the nerve gland situated near its base. The two lemnisci are filamentous structures and some times reach up to the anterior end of the posterior testis. Each lemnisci has 3 nuclei.

The male genitalia consists of two oval testes, situated one behind the other and closely apposed. The vasa efferentia from the testes join each other near the prostatic gland and form the vas deferens, which ends in a muscular cone-shaped penis. Prostatic gland is a

[1] Van Cleave, H. J.—Two New Genera and Species of Acanthocephala from fishes of India. *Rec. Ind. Mus.*, XXX, pp. 147-149 (1928).

[2] Datta, M. N.—Scientific results of the Yale North India Expedition. *Biological Report No. 20.* Helminth parasites of Fishes from North India, with special reference to Acanthocephalans. *Rec. Ind. Mus.*, XXXVIII, pp. 211-229 (1936).

single syncytial mass having 6-8 nuclei in it. It leads into a prostatic reservoir which gives out a prostatic duct leading to the base of the penis. There is a baloon-shaped, thin-walled seminal vesicle and an eversible bursa.

The female genitalia agrees with the description of *E. devdevi* of the author (1936).

Measurements.—Males 2·4—7·5 mm. × 0·65—0·92 mm.; females 4·8—12·0 mm. × 0·7—1·5 mm.; proboscis 1·21 × 1·10 mm.; proboscis sheath 0·35 × 0·22 mm.; lemnisci (i) 4·31 × 0·24 mm., (ii) 3·92 × 0·24 mm.; testis anterior 1·12 × 0·65 mm., posterior 1·10 × 0·70 mm.; prostatic gland 0·79 × 0·40 mm.; prostatic reservoir 0·24 × 0·15 mm.; seminal vesicle 0·62 × 0·22 mm.; bursa 0·88 × 0·40 mm.; hooks anterior 0·130 mm., middle 0·050 mm., basal 0·045 mm.

Allotype.—In the collections of the Zoological Survey of India, Indian Museum, Calcutta.

Host.—*Scizothorax zarudnyi* (*Nikolsky*).

Location.—Intestine.

Locality.—Hamun-i-Helmand near Labi.

I wish to record my grateful thanks to Dr. Baini Prashad, Director, Zoological Survey of India, Indian Museum, Calcutta, for giving me facilities and direction in my work. I must also record my gratefulness to my colleague the late Mr. Dev Dev Mukerji, who gave me the parasites he found in the fishes in the course of his work on the intestinal contents of fishes.

MGIPC—M—III-8-5—21-9-37—400.

INDIAN EARTHWORMS.

II. *Scolioscolides*, Gen. Nov.

By G. E. Gates, *Judson College, Rangoon.*

Contents.

	Page.
Introduction	305
Scolioscolides, gen. nov.	305
Systematic relationships of *Scolioscolides*	305
Scolioscolides bergtheili (Michaelsen)	307
References	310

Introduction.

On studying the descriptions of the Indian species of *Megascolides*, it was noted that one, *M. bergtheili* Michaelsen 1907, is distinguished from all other Indian species by a combination of characteristics that is also found in the genus *Eutyphoeus*. Examination of the types shows that *bergtheili* actually is marked by a complex of characteristics so distinctive as to necessitate generic separation.

The author's thanks are tendered to Dr. B. Prashad, Director of the Zoological Survey of India, for the opportunity of examining these interesting worms.

Scolioscolides, gen. nov.

Diagnosis.—Setae lumbricine. Bithecal, spermathecal pores on 7/8. Male pores on xviii. One gizzard in a space formed by the disappearance of septa 6/7—7/8. Calciferous glands, intestinal caeca (both paired and unpaired) and supra-intestinal glands as in *Eutyphoeus*. Last hearts in xiii. Excretory organs (closed exonephric?) micronephridia. Holandric. Prostates tubular. Vasa deferentia pass into the entalmost portion of the prostatic duct. Spermathecal diverticula open into ental portion of the duct.

Genotype and only species, *Megascolides bergtheili* Michaelsen 1907.

Distribution.—Known only from the type locality. Especially noteworthy is the nearness of that locality to the central portion of the *Eutyphoeus* area.

Remarks.—The definition above is tentative and liable to modification if and when other species are found but for the present at least, adequately distinguishes the genus from all other Megascolecid genera.

Systematic Relationships of *Scolioscolides*.

Scolioscolides is remarkably like the genus *Eutyphoeus* and especially certain holandric species of that genus. Similarities are as follows: muscularity of septa 4/5—5/6 and 8/9—10/11, absence of 6/7—7/8, close crowding of 8/9—10/11; location of the hearts of vi-viii with relation

to the gizzard, presence of hearts in xiii ; presence of a single, large gizzard, of paired and unpaired intestinal caeca and of characteristic calciferous and supra-intestinal glands with associated modifications of the vascular system ; closed, exonephric(?), micronephridial excretory organs ; size and location of spermathecal pores and number and structure of spermathecae ; tubular prostates. In addition, and in part at least of minor importance, may be mentioned : secondary annulation ; paired female pores ; the genital markings which are similar to those often found in *Eutyphoeus* ; the number and location of the seminal vesicles ; and the band of nephridial tubules in iii. Furthermore the median and unpaired, ventral intestinal caeca are known only from *Scolioscolides* and *Eutyphoeus*.

In contrast to the list above, a statement of differences between *Scolioscolides* and a considerable portion of the holandric section of *Eutyphoeus* comprises only the following : absence of penial setae, rudimentary condition of the typhlosole, location of the male pores on xviii, ental union of the vasa deferentia and the prostatic duct to open to the exterior by a common aperture. Of these, only the latter two now appear to be of especial importance.

Scolioscolides is Megascolecine (Stephenson 1930) or Megascolecid (Michaelsen 1921). *Eutyphoeus* is equally clearly Octochaetine (Stephenson 1930) or Acanthodrilid (Michaelsen 1921). But *Eutyphoeus* and *Scolioscolides*, if morphological similarity is valid evidence of relationship and if the extent of that similarity is an index of the closeness of relationship, are much more closely related to each other than either is to any other known genus. Transfer of either genus to the other subfamily or family will force the elimination from the definition of the subfamily or family of just those characteristics that alone distinguish it from the other subfamily or family. Union of the two subfamilies (or families) is undesirable as the group so produced cannot be defined morphologically.

Convergence, an explanation that might have been acceptable to Stephenson, permits the retention of the two genera within the Octochaetinae and Megascolecinae (or Acanthodrilidae and Megascolecidae) without modification of present definitions. But such retention is possible only by abandoning, almost entirely, morphological similarity in favour of hypothetical phyletic seriation as a basis for classification.

Recent classifications (Michaelsen 1921 and Stephenson 1930) have been marked by limitation of reference, especially in generic diagnoses, to a few organs, structures or characteristics, and with more attention to, and greater emphasis on, phyletic seriation than morphological similarity. Such procedures have produced families and genera admittedly polyphyletic or under suspicion of polyphyly ; groups in which morphologically dissimilar forms are closely related while morphologically similar groups are only distantly related ; in one case at least, a generic definition that " is so indefinite as to be meaningless " (Stephenson, 1930, p. 867); and have led Stephenson (1921) to argue for morphologically identical though phylogenetically distinct genera. In these circumstances, as might be expected, some of the family and (or) subfamily definitions are little more than statements of assumed evolutionary development.

Thus the only morphological distinction between the subfamilies Megascolecinae and Octochaetinae (Stephenson, 1930) is the union of the male and prostatic apertures in the former and the lack of such union in the latter, a characteristic that has been denied even generic value at times by both Stephenson and Michaelsen.

This discussion will be continued and also concluded, for the present, in the section on phylogenetic relationships of the next article in this series, " Indian earthworms. III. The genus *Eutyphoeus*."

Scolioscolides bergtheili (Michaelsen).

1907. *Megascolides bergtheili*, Michaelsen, *Mitt. Mus. Hamburg*, XXIV, p. 150. (Type locality, Sandakphu in Darjiling district, Eastern Himalayas. Types in the Indian and Hamburg Museums).

1909. *Megascolides bergtheili*, Michaelsen, *Mem. Ind. Mus.* I, p. 159.

1910. *Megascolides bergtheili*, Michaelsen, *Abh. Nat. Ver. Hamburg*, XIX, (5), p. 9.

1916. *Megascolides bergtheili*, Michaelsen, *Mjöbergs Austral. Exp.* p. 48. (Prostates).

1923. *Megascolides bergtheili*, Stephenson, *Oligochaeta*, in *F. B. I. Series*, p. 196.

Material examined.—From the Indian Museum ; 2 clitellate, undissected specimens labelled, " *Megascolides bergtheili* Michaelsen. Sandakphu, B. Sikkim. Messrs. Bergtheil and Burkill. Types. ZEV 2951/7." One of the specimens is ruptured in a postclitellar region.

Not examined.—3 specimens from the type series in the Hamburg Museum.

External characteristics.—There is a well developed secondary annulation similar to that found in species of *Eutyphoeus* and *Tonoscolex*. On iv there is a single, deep, postsetal secondary furrow ; on v, a slight presetal and a deep postsetal furrow ; on vi, a slight presetal, a deep postsetal and a slight postsetal ; on vii, as on vi ; on viii, a slight presetal, a deep presetal, a deep postsetal and a slight postsetal ; on ix, a slight presetal, a deep presetal and two slight postsetal furrows ; on x, a deep presetal, a deep postsetal, a slight postsetal ; on xi and xii, a deep presetal and a deep postsetal (listed in anteroposterior order).

The setae begin on ii and are small. On x, $ab < cd < aa < bc$ while on xxii $ab < cd < bc$ but bc is only very slightly greater than cd, while ab and cd are nearly equal ; at the middle of the body cd is very slightly smaller than bc which is smaller than aa. Setae a and b of xviii are lacking or invisible.

The first dorsal pore is on 11/12 (2), a pore-like but apparently nonfunctional marking on 10/11 (one specimen).

The clitellum is reddish brown, conspicuously protuberant (except on xiii), extending from 12/13 to 17/18 and possibly very slightly onto xviii. Intersegmental furrows and dorsal pores (except on 12/13 and 17/18) are lacking but the sites of the pores are indicated by tiny depressions, setae present but deeply retracted, the tips visible only as minute black dots at the bottom of tiny crater-like depressions.

The spermathecal apertures are on 7/8, in ab, slightly median to b.

There is a pair of female pores anteriorly on xiv, each just anterior and median to a, the pores located in paired or unpaired transversely slit-like depressions.

The male pores are small, transversely crescentic, the concave side of the crescent facing anteriorly, the centre about on line *b*, each pore on the ventral face of a slightly protuberant, almost circular, rather soft papilla, the anterior half of which is very slightly more protuberant than the posterior half, the papilla in *ab* but extending slightly median to or nearly to *a* and laterally into *bc*. Each tubercle is surrounded by a thick, conspicuously raised rim that is sharply demarcated peripherally and separated from the male pore tubercle by a narrow but fairly deep groove. As a result of the presence of this groove the male pore tubercle has a rather shortly penis-like appearance. Rim and tubercle together constitute a porophore that is shortly elliptical in outline, transversely placed, extending mesially nearly to the mid-ventral line, laterally nearly to mid *bc*, anteriorly to the presetal secondary furrow and posteriorly to 18/19. The porophores are connected mid-ventrally by a low, wrinkled ridge that is restricted to the middle (setal) annulus of xviii.

The genital markings are unpaired and segmental, on xii, xiii, xx, a half-marking on xxi on the left side. The markings extend anteriorly to the intersegmental furrow, posteriorly to the postsetal secondary annulus or to or nearly to the intersegmental furrow, setae *a* and *b* on the marking and always nearer to or actually on the posterior margin. The markings extend laterally into the median portion of *bc*. Each marking has a sharply demarcated, conspicuously protuberant, narrow rim. The area within the rim appears to be depressed but actually is about at the general epidermal level, the surface smooth and flat. This central portion has a greyish translucent appearance, with a faint indication at the mid-ventral line of being marked off into two distinct portions. The marking of xxi is on the left side but extends mesially slightly onto the right side. On the second specimen the markings are on xi, xii, xiii and xx. The marking of xi has the anterior and posterior portions of the rim united at the mid-ventral line to separate completely two central areas.

Internal anatomy.—Septa 4/5—5/6 are thickly muscular, 6/7—7/8 lacking; 8/9—10/11 muscular and fairly close together behind the gizzard; 11/12 delicate and transparent but apparently complete. The last five segments are filled with a brownish, granular material in which are embedded parasitic cysts.

The gizzard is large, in the space between 5/6 and 8/9. The intestine begins in xv (2). The calciferous glands are in xii and are of the *Eutyphoeus* type. More than 50 vertical partitions were counted in one gland. The intestinal caeca are in xxi, pointed, small but quite definite, arising from the dorsal side of the gut and directed dorsally, except that in the second specimen the left caecum though rising dorsally is bent anteriorly. There are five mid-ventral, unpaired intestinal caeca, in xxiv-xxviii. Each of these caeca is fairly large, about 1 mm. long, with pointed tip, gradually widened passing posteriorly and dorsally to the gut. The apertures into these caeca on the floor of the gut are oval, large and readily visible, a viscid slime in which are flocculent brownish particles passing through the aperture into the caecal lumina. The typhlosole is represented only by a low ridge that terminates posteriorly with the supra-intestinal glands. The supra-intestinal glands are two pairs located either in lix-lx or lx-lxi the anterior pair less than half the

size of the posterior. These glands have an internal structure and attachment to the gut similar to that in *Eutyphoeus.*

The last pair of hearts is in xiii (2). There is a pair of hearts in each of segments ix-xii. Posterior to the gizzard and just in front of 8/9 the dorsal blood vessel gives off two pairs of vessels (hearts of vii and viii) which pass ventrally and (apparently) into the ventral trunk. These commissures are not filled with blood, are covered by a furry sort of tissue and in addition are bound to the ventrolateral trunks near the ventral blood vessel by tough, opaque connective tissue. The dorsal blood vessel is continued anteriorly into iv. Just anterior to the gizzard the dorsal blood vessel gives off a pair of vessels (hearts of vi) which pass ventrally and possibly into the ventral trunk though this connection has not been identified definitely. Heart-like commissures are visible in iv and v. The ventrolateral trunks were noted only in vi-viii. In xii-xiii a supra-oesophageal trunk is present (second specimen). This vessel bifurcates in xii, each of the two branches passing laterally at right angles to the trunk and at the margin of the gut breaking up into three branches which pass into the gut wall. Posteriorly the supra-oesophageal is not visible behind 13/14 and in xiii gives off on each side several branches to the dorsal face of the gut. From segment lxi or lxii posteriorly for several segments there is protuberant into the lumen of the gut from the floor at the midventral line a conspicuous, blood-filled longitudinal vessel. Anteriorly this vessel divides into two branches that are visible on the coelomic wall of the gut as they pass dorsally in lx or lxi into the supra-intestinal gland of the segment. No subneural has been found in the posterior portion of the body.

In iii, on each side, there is a transversely placed band of nephridial tubules on the parietes. The excretory organs are micronephridia. From xii posteriorly there is usually a nephridium on each side just dorsal to *d*, another in, just dorsal or ventral to line *c*, and several closely crowded in the median portion of *bc*. In the posteriormost 60 segments the median nephridium on each side in each segment is quite obviously larger than the other nephridia but just as obviously is a micronephridium.

The testicular coagulum in each of segments x and xi is compacted into a hard mass ; that in x U-shaped, that in xi annular and completely surrounding the gut. The mass in xi very much resembles a testis sac such as is found in certain species of *Eutyphoeus* but it was not possible to separate off from the testicular coagulum anything in the way of a bounding membrane although such may have been present. The hearts of xi are imbedded at least in part in the coagulum but slip out on slight manipulation leaving a definite groove. The male funnels are characterized by a brilliant iridescence. The seminal vesicles of xii are medium sized, not reaching up to the dorsal blood vessel but pushing 12/13—13/14 back into contact with 14/15. Each of these vesicles is tough, the margin incised. The vesicles of ix are vertically placed on the anterior face of 9/10.

The prostates are confined to xviii-xix, tubular, the lumen small, slit-like, central or nearly so. The duct is about 1¾ mm. long, whitish, with a slight sheen, the ectal 1 mm. slightly thicker and straight, the

ental portion looped. The vasa deferentia pass into the duct shortly after the latter emerges from the prostatic gland.

The spermathecal duct is shorter than the ampulla, not abruptly narrowed within the parietes, rather flattened antero-posteriorly, the relatively large lumen irregular due to a vertical ridging of the wall. The diverticula which pass into the duct on the right and left sides are practically sessile and are characterized by a spermatozoal iridescence. Each diverticulum is shortly ellipsoidal or more or less definitely marked off into two or three lobes.

The longitudinal musculature is uninterrupted above the genital markings.

Remarks.—The diagnosis, admittedly tentative, is similar in form to that developed in course of a revision of the Indian species of *Eutyphoeus*.

Diagnosis.—Male pores small, transversely crescentic, centres about on *b*, each pore on the ventral face of a small, rather penis-like papilla at the centre of a porophore of transversely and shortly elliptical outline that extends from the presetal secondary furrow to 18/19 and from just lateral to the mid-ventral line into mid *bc*. Genital markings unpaired, on (xi) xii-xiii, xx (xxi), primarily presetal(?) but extending posteriorly to or nearly to the intersegmental furrow and laterally into mid *bc*. Female pores paired. Spermathecal pores in *ab*. First dorsal pore on 11/12. Unpigmented(?). Length 100-120 mm. Diameter 4½-5 mm.

Lateral intestinal caeca in xxi; ventral caeca in xxiv-xxviii. Supra-intestinal glands in lix or lx to lx or lxi. Dorsal blood vessel continued into iii with hearts in iv-vi. Holandric; testis sac annular(?). Spermathecal diverticula paired, median and lateral. Longitudinal musculature uninterrupted above the genital markings.

Distribution.—Known only from the type locality, Sandakphu, Darjiling district, Bengal.

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SYSTEMATIC POSITION, GEOGRAPHICAL DISTRIBUTION AND EVOLUTION OF THE CYPRINOID GENERA WITH A PROCUMBENT PREDORSAL SPINE.

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The *Mystacoleucus*-group of Cyprinoid genera, comprising *Mystacoleucus* Günther[1], *Matsya* Day,[2] *Spinibarbus* Oshima[3] and *Spinibarbichthys* Oshima,[4] is characterised by the presence of a forwardly directed spine in front of the dorsal fin. *Mystacoleucus* is distinguished from the other three genera by its relatively long anal fin, containing 8-10 branched rays as against the usual number 5. *Matsya* (=*Acanthonotus* Day[5]) and *Spinibarbichthys* possess a serrated dorsal spine, whereas in *Spinibarbus* the dorsal spine is smooth. In elucidating the systematic position of these genera most of the workers do not appear to have paid attention to the generic characters of Day's *Matsya*. Smith,[6] who regarded it as congeneric with *Mystacoleucus*, gave no morphological details for his views. Unfortunately no specimen[7] of *Matsya argentea* Day is available for study either in the Indian Museum or in the Bureau of Fisheries Bangkok. Three specimens of *Mystacoleucus marginatus* (Cuv. & Val.) were sent to me in 1932 by Dr. H. M. Smith with the remark : "Are these *Matsya argentea* Day ?" This observation indicates that Smith had confused either a colour variety of the common species *M. marginatus* with Day's form or he may have obtained specimens of the species—*M. chilopterus* recently described from Siam by Fowler[8]. It may further be noted that Suvatti in his "Index to Fishes of Siam" lists only one species of *Mystacoleucus, M. marginatus* (C. V.), which is recorded from Northern, Central and Peninsular Siam. Day's diagnosis of *Matsya* is, however, fairly complete and it leaves no doubt that *Spinibarbichthys* should be regarded as a synonym of *Matsya*. In most of the Cyprinoid genera the nature of the dorsal spine, whether serrated or entire, strong and bony or feeble and articulated, is not considered of sufficient importance for separating genera. I am, therefore, in agreement with Nichols and Pope,[9] Nichols[10], Myers,[11] Mukerji,[12]

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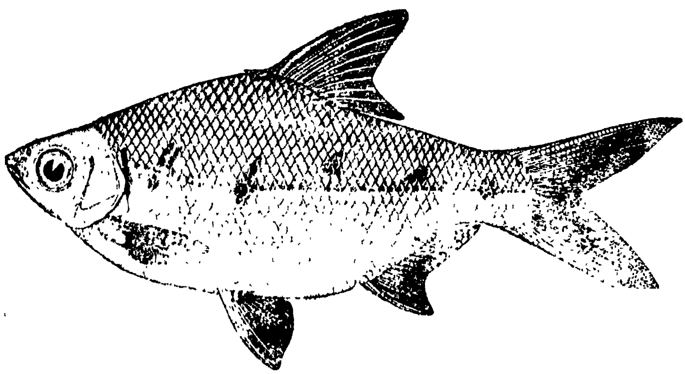
[1] Günther, *Cat. Fish. Brit. Mus.*, VII, p. 206 (1868).
[2] Day, *Faun. Brit. India*, Fish, I, p. 292 (1889).
[3] Oshima, *Ann. Carnegie Mus.*, XII, p. 217 (1919).
[4] Oshima, *Annot Zool. Japan*, XI, p. 10 (1926).
[5] Day, *Fish. India*, (Suppl.), p. 807 (1888).
[6] Smith, *Journ. Siam. Soc., Nat. Hist. Suppl.*, VIII, p. 185 (1931) ; *ibid.*, IX, p. 79 (1933).
[7] Day's description of *Matsya argentea* was based on Tickell's manuscript description and figure of the species. Presumably Day did not examine any specimen of *M. argentea*.
[8] Fowler, *Proc. Acad. Nat. Sci. Philadelphia*, LXXXVII, p. 112 (1935).
[9] Nichols and Pope, *Bull. Amer. Mus. Nat. Hist.*, LIV, pp. 343, 344 (1927).
[10] Nichols, *Bull. Amer. Mus. Nat, Hist.*, LVIII, pp. 11, 12 (1928).
[11] Myers, *Lingnan Sci. Journ.*, X, pp. 258, 259 (1931).
[12] Mukerji, *Rec. Ind. Mus.*, XXXIV, p. 284-286 (1932).

Mori[1] and Tchang[2] that *Spinibarbus* and *Spinibarbichthys* should be regarded as congeneric. Both these genera should, therefore, be assigned to the synonymy of *Matsya*. For the sake of convenience and on geographical grounds, it may, however, be desirable to treat *Spinibarbus* as a subgenus of *Matsya*.

In the four species of *Mystacoleucus*[3] known so far, *M. marginatus*, *M. padangensis*, *M. chilopterus* and *M. atridorsalis* Fowler,[4] the number of branched rays in the anal fin varies from 8 to 10 and I agree with Mukerji (*op. cit.*) that on this character alone they should be recognised as belonging to a distinct genus. It may here be noted that in a great majority of Cyprinoid genera there are only 5 branched rays in the anal fin. Any variation from this standard is, therefore, of special significance.



TEXT-FIG. 1.—Lateral view of *Mystacoleucus ogilbii* (Sykes). ×⅘.

Recently I collected two specimens of *Rohtee ogilbii* Sykes[5] (text-fig. 1) at Kurnool which possess a well-marked procumbent, predorsal spine. Other specimens of the same species in the collection of the Indian Museum were examined and a predorsal spine, sometimes hidden below the scales (text-fig. 2 *a*) was found in all of them. In this species the number of branched anal rays varies from 13 to 14, and the number of scales in the lateral line is about 55. Its pharyngeal bones and teeth are similar to those of *Mystacoleucus* (text-figs. 2 *b* & *d*), and its scales also show a close resemblance to those of *M. marginatus* (text-figs. 2 *c* & *e*). It seems reasonable, therefore, to include *Rohtee ogilbii* in the genus *Mystacoleucus*, the definition of which should be emended to comprise forms having 8-14 branched rays in the anal fin. In none of the other species of *Rohtee*, such as *R. bakeri* Day, *R. cotio* (Ham.), *R. duvaucelli* (Cub. & Val.), *R. vigorsii* Sykes, *R. belangeri* (Cuv. & Val.) and *R. feae* (Vinciguerra), I was able to detect any predorsal spine.

[1] Mori, *Studies on the Geographical Distribution of Freshwater Fishes in Eastern Asia* (Chosen : 1936). In the various lists of Chinese fishes *Spinibarbus* is recognised as a valid genus, while *Spinibarbichthys* is considered a synonym of *Spinibarbus*.

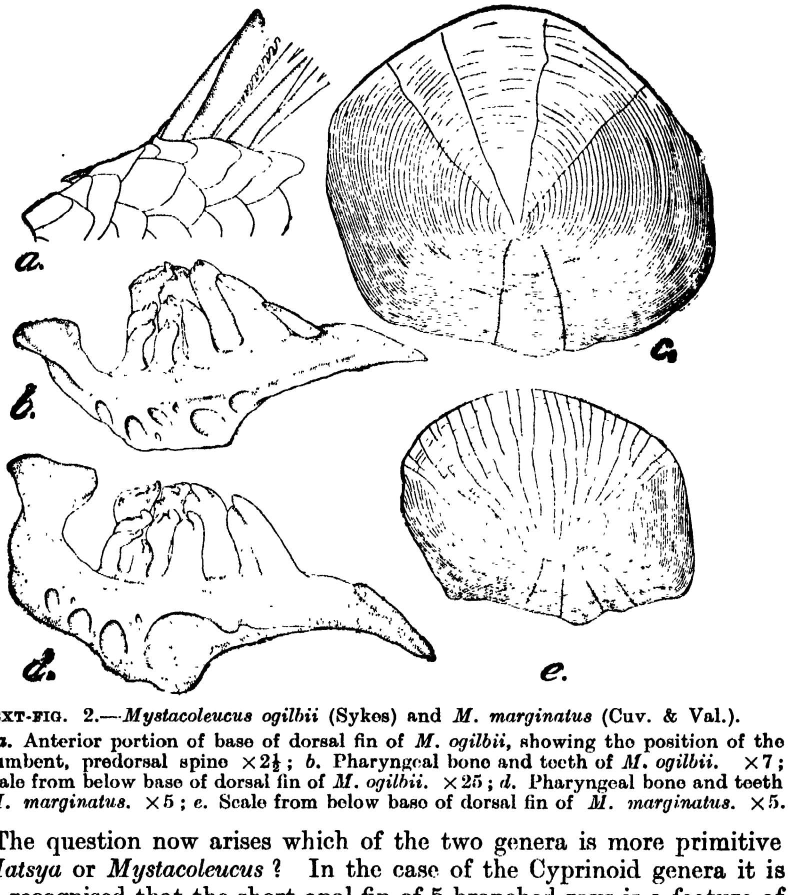
[2] Tchang, *Zoologia Sinica*, II, p. 43 (1936).

[3] For up-to-date descriptions of *Mystacoleucus marginatus* (Cuv. & Val.) and *M. padangensis* (Blkr.) see Weber and de Beaufort, *Fish. Indo-Austral. Archipel.*, III, pp. 108-110 (1916).

[4] Fowler, *Proc. Acad. Nat. Sci. Philadelphia*, LXXXIX, p. 196 (1937).

[5] Sykes, *Trans. Zool. Soc. London*, p. 36 (1841).

The relationship of these species of *Rohtee* with Sykes' *R. ogilbii* is discussed later (*vide infra* p. 314).



TEXT-FIG. 2.—*Mystacoleucus ogilbii* (Sykes) and *M. marginatus* (Cuv. & Val.).

a. Anterior portion of base of dorsal fin of *M. ogilbii*, showing the position of the procumbent, predorsal spine $\times 2\frac{1}{2}$; *b.* Pharyngeal bone and teeth of *M. ogilbii.* $\times 7$; *c.* Scale from below base of dorsal fin of *M. ogilbii.* $\times 25$; *d.* Pharyngeal bone and teeth of *M. marginatus.* $\times 5$; *e.* Scale from below base of dorsal fin of *M. marginatus.* $\times 5$.

The question now arises which of the two genera is more primitive —*Matsya* or *Mystacoleucus*? In the case of the Cyprinoid genera it is well recognised that the short anal fin of 5 branched rays is a feature of specialisation, while in the primitive forms, such as *Opsariichthys*, *Chela*, *Barilius*, etc., the anal fin is fairly long. It would, therefore, seem probable on *a priori* grounds that *Mystacoleucus* represents a less specialised form than *Matsya*.

As indicated above the emended genus *Mystacoleucus*, especially the form *M. ogilbii*, shows great affinities with the members of the genus *Rohtee*, and it would be useful, therefore, to examine in the first place the precise limits of *Rohtee* and of its allied genera also.

In the species of *Rohtee* known from India and Burma[1], with the exception of *R. cunma* Day, the dorsal fin possesses a strong serrated spine and the number of branched anal rays varies from 11 in *R. bakeri* Day to 33 in *R. cotio* (Ham.). *R. cunma* was described by Day[2] from Moulmein and its dorsal fin is characterised by the possession of a " spine

[1] For description of most of the Indian and Burmese species of *Rohtee* see Day's *Fishes of India* and the " Fauna " volumes.

[2] Day, *Fish. India*, (Suppl.), p. 807 (1888).

weak and longer than the head, not serrated." Unfortunately no specimen[1] of this species is available for study. Vinciguerra[2], on the nature of the dorsal spine alone, doubted its inclusion in the genus *Rohtee*. Again Tchang's[3] separation of his *Parosteobrama* from *Osteobrama* Heckel[4] (=*Rohtee*) was also based on this feature. Fu and Wang[5] have, however, shown that Tchang's *Parosteobrama* is in reality *Parabramis* Bleeker and with this view Mori (*op. cit.*) agrees. Mukerji[6] doubted the advisability of separating *Parosteobrama* from *Rohtee* only on the nature of the dorsal spine. Thus, as in the case of *Matsya* (*vide supra*, p. 312), we have two groups of species in *Rohtee*, those with the dorsal spine serrated (*Rohtee* s. s.) and those with the dorsal spine smooth (*Parabramis*). In most of the species of *Rohtee* the abdominal edge is sharp and trenchant only behind the bases of the ventrals (*Rohtee* s. s.) whereas in *R. belangeri* (C. V.) the whole of the abdominal edge is sharp (*Smiliogaster* (Bleeker[7]). Similarly among Chinese fishes we have *Chanodichthys* Bleeker,[8] *Parabramis* Bleeker[9] and *Megalobrama* Dybowski[10] which are distinguished from one another by the nature of the abdominal edge. It is thus seen that *Rohtee* and the allied forms constitute a very generalised group showing considerable diversity in form and structure. Ignoring the nature of the abdominal edge and taking into consideration the nature of the dorsal spine, as in the case of *Matsya* and *Spinibarbus*, it may be useful to regard *Parabramis* as a subgenus of *Rohtee* on geographical grounds.

The geographical distribution of the genera *Matsya* and *Mystacoleucus* is very significant. *Matsya* of the *Spinibarbus*-type is known from Formosa [*M. hollandi* (Oshima) and *M. elongatus* (Oshima)], Fukien [*M. caldwelli* (Nichols)] and Hainan [*M. nigrodorsalis* (Oshima)]; while that of the *Spinibarbichthys*-type is found in Hainan [*M. denticulatus* (Oshima)], Szechwan [*M. pingi* (Tchang)] and Tenasserim [*M. argentea* Day]. The members of the two types meet in Hainan, but it may be noted that the forms found towards the west and the south are better armed than those found towards the east. *Mystacoleucus* is found in Siam [*M. marginatus* (Cuv. & Val.), *M. chilopterus* Fowler and *M. atridorsalis* Fowler], South Burma [*M. marginatus* (Cuv. & Val.)], Malay Peninsula [*M. marginatus* (Cuv. & Val.)], Sumatra [*M. marginatus* (Cuv. & Val.) and *M. padangensis* (Blkr.)], Java and Borneo [*M. marginatus* (Cuv. & Val.)] and the Deccan [*M. ogilbii* (Sykes)]. Here again in the more southern forms the dorsal spine is fully armed.

The geographical distribution of the fishes of the *Rohtee* and *Parabramis* groups is also interesting. Species of *Rohtee* are known from

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[1] As in the case of *Matsya argentea*, Day's description of this species is based on Tickell's manuscript description and figure. Presumably he had no specimen of *Rohtee cunma*.

[2] Vinciguerra, *Ann. Mus. Civ. Stor. Nat. Genova*, (2), IX, p. 188 (1890).

[3] Tchang, *Bull. Soc. Zool. France*, LV, pp. 46-52 (1930).

[4] Hora, *Rec. Ind. Mus.*, XXII, pp. 187, 188 (1921), has already explained why *Rohtee* Sykes should have preference over *Osteobrama* Heckel.

[5] Fu and Wang, *Contrib. Biol. Lab. Sci. Soc. China*, VIII, *Zool. Ser.* No. 10 (1932).

[6] Mukerji, *Journ. Bombay Nat. Hist. Soc.*, XXXVII, pp. 69-71 (1934).

[7] Bleeker, *Nat.-Tijdschr. Neder.-Indie*, XX, p. 428 (1859).

[8] Bleeker, *ibid*, p. 432 (1859).

[9] Bleeker, *Nederl. Tijdschr. Dierk.*, II, p. 21 (1865).

[10] Dybowski, *Verh. Zool-bot Gess. Wien.*, XII, p. 212 (1872).

Yunnan [*R. belangeri* (Cuv. & Val.), *R. cotio* (Ham.) and *R. microlepis* (Blyth)] and Burma and India (several species, mostly found in Peninsular India). Fishes of the *Parabramis*-type are found in the Amur System, North China, Kiao-Ho, Yangtse-Kiang, Hainan (several species) and Burma (only one species—*P. cunma*).

If the above distributional records are correlated with the extent of the anal fin, we notice that the forms possessing 5 branched rays in the anal fin (*Matsya*) are restricted to Southern China (Formosa, Fukien, Szechwan and Hainan) while one species (*M. argentea*) is also found in the interior of Tenasserim. The *Mystacoleucus*-type, with 8-14 branched rays, is restricted to Siam, Lower Burma, the Malay Archipelago and the Deccan. The *Rohtee*-type (long anal and serrated dorsal spine) is common in Peninsular India, other parts of India, Burma and Yunnan. The *Parabramis*-type (long anal and smooth dorsal spine) is common throughout China and only one species is found in Burma. As indicated above, in the Cyprinoid fishes a short anal fin of 5 branched rays is to be regarded as a feature of specialisation and it would, therefore, seem probable that *Rohtee* and *Parabramis* represent the ancestral forms of the entire group of fishes discussed above. Considering the present-day density of population of the various forms it seems probable that the centre of origin of these fishes was situated somewhere in South China. The diversity of form and specialisation, therefore, seems to have originated in this region and those species that spread towards north and north-west had probably to face less rigorous conditions of existence and did not, therefore, develop fierce, serrated dorsal spine; whereas those that spread towards south and south-west or remained in Southern China had to contend with more disturbed conditions due to the birth of the Himalayan chain of mountains and developed a strong, denticulated spine. *Rohtee cunma*, like *Matsya argentea*, is, however, an exception; it is found in Burma but corresponds to the forms that spread northwards. Its localised distribution signifies that it is a stray element of the northern-type that probably came to Burma with some later waves of migration.

As the ancestral stock travelled towards the south, the number of anal rays became fewer and fewer so that we get the *Mystacoleucus*-type in the Malay Archipelago on the one hand and in Peninsular India on the other. In the case of *Rohtee*, the species with the largest number of anal rays—*R. cotio*—is widely distributed from Southern China to Burma and India; while that with the smallest number of rays—*R. bakeri*—is found in the southernmost extremity of India. The greatest specialisation of all these forms, however, took place in Southern China, their ancestral home, where the fishes of the group possessing 5 anal branched rays, with the exception of *Matsya argentea*, are found today. It may here be noted that these fishes, with the exception of *Rohtee bakeri* Day, are not found south of the Cauvery watershed and neither have they spread to Ceylon or Africa. This point is discussed later (*vide* p. 318).

Many have regarded the predorsal spine as a character of great taxonomic importance, but Rendahl[1], who investigated its morphology,

[1] Rendahl, *Ark. Zool.*, XXIV A, No. 16, pp. 67-74 (1932).

considers it as a feature of convergence. By convergence we usually mean the presence of the same or a similar character in phylogenetically distantly related forms, and further it implies that the character is of special utility to the individuals concerned, for convergence is the result of adaptation of different organisms to a similar type of environmental conditions. In the case of the predorsal spine it is difficult to understand how it can be used as an organ of defence or offence. If, however, the morphology of the dorsal fin of all the forms referred to above is taken into consideration it may be possible to trace its probable mode of origin and to assign to it some definite function.

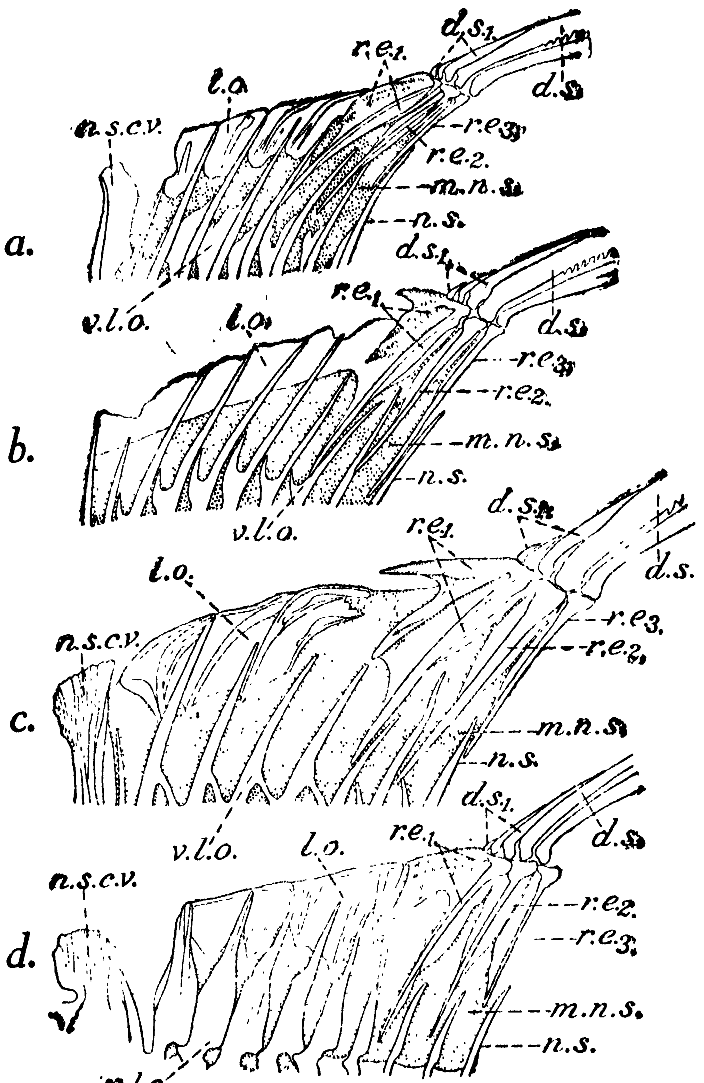
A very characteristic feature of *Rohtee* and *Parabramis* is that both the dorsal and the ventral surfaces are provided with sharp edges—especially the portion of the dorsal surface in front of the dorsal fin and, that of the ventral surface behind the ventral fins. To support the sharp edge immediately in front of the dorsal fin the anterior portion of the first radial of the fin (text-fig. 3) is so modified that its distal edge trails close to the surface. In front of the radial elements there is a series of well-developed lamellar ossicles which lie between the neural spines of the adjacent vertebrae; these not only present a suitable surface for the attachment of muscles but also provide the necessary support for the keeled dorsal edge. Anteriorly these ossicles are replaced by the compressed neural spine of the compound vertebra and the supra-occipital crest. Bridge[1] described a similar series of bony elements in *Abramis brama* and *Tinca tinca* and concluded that "These ossicles are proximal segments of the fin supports of the atrophied anterior section of the dorsal fin." Whatever may be their phylogenetic significance, their presence is undoubtedly meant to provide a support to the sharp dorsal edge.

For the probable mode of origin of the pre-dorsal spine we may consider the structure of the dorsal fin of *Rohtee duvaucelli* (C. V.), *Mystacoleucus ogilbii* (Sykes) and *M. marginatus* (C. V.).

In *Rohtee duvaucelli* (text-fig. 3 *a*) the character of the radial skeletal elements of the dorsal fin is more or less similar to that of the four Cyprinoid types described by Bridge (*op. cit.*) except that its first radial element (*r. e.*) is better developed and its antero-dorsal border lies just below the sharp edge of the dorsal surface. It is preceded by a continuous series of lamellar ossicles (*l. o.*) which lie between the neural spines of the adjacent vertebrae. The median region of each ossicle is thickened to form a ridge-like structure. Near the bases of the neural spines, a further series of lamellar ossicles (*v. l. o.*) is developed from the anterior borders of the neural spines. Anteriorly they become more extensive and form broad supporting laminae between the neural spines. In *R. ogilbii* (text-fig. 3 *b*) the structures are similar to those of *R. duvaucelli* except that the first radial element (*r. e.*) is produced forward as a short spine, the lamellar ossicles are broad and thin. The ventral lamellar osicles near the bases of the neural spines have, more or less, coalesced with the spines, so that a forwardly directed outgrowth of the neural spine gives support to the neural spine of the vertebra anterior to it.

[1] Bridge, T. W.—The Mesial Fin of Ganoids and Teleosts. *Journ. Linn. Soc. London* (Zool.), XXV, p. 549 (1896).

In *R. marginatus* (text-fig. 3 *c*) the forwardly directed predorsal spine is considerably larger and the dorsal lamellar ossicles are provided with



Text-fig. 3.—The skeletal elements of the dorsal spine and of the region in front of it in *Rohtee* Sykes, *Mystacoleucus* Günther and *Barbus* Cuvier.

a. Rohtee duvaucelli (Cuv. & Val.); *b. Mystacoleucus ogilbii* (Sykes); *c. M. marginatus* (Cuv. & Val.); *d. Barbus kolus* Sykes.

d. s.=Last dorsal spine; *d. s.*$_1$.=Vestigeal dorsal spines; *l. o.*=Dorsal lamellar ossicles; *m. n. s.*=Membrane between neural spines; *n. s.*=Neural spine; *n. s. c. v.*= Neural spine of compound vertebra; *r. e.* 1. to *r. e.* 3.=Radial elements of the spines and the anterior fin rays; *v. l. o.*=Ventral lamellar ossicles.

strengthening ridges. The ventral lamellar ossicles are replaced by solid, bony columns between the adjacent vertebrae. Thus in the

three types described above we find that there are bony elements to strengthen the dorsal edge of the fish and that supports are developed to keep the neural spines in position and to prevent them from bending backwards. All these devices are probably meant to combat the stress imposed on the fish as it swims rapidly through water. Under such circumstances the utility of the predorsal spine would seem to present a stream-like wedge to the water before it approaches the dorsal fin. In the earlier stages of the flattening of the keeled dorsal surface it seems probable that more work was thrown on the predorsal spine. This assumption is borne out by the fact that the spine becomes larger and more powerful in the series of forms represented by *Mystacoleucus ogilbii*, *M. marginatus*, and *Matsya pingi*. (The spine of the last species was described and figured by Rendahl). When, however, the entire dorsal surface became stream-lined, the predorsal spine gradually disappeared. Such a course of evolution would indicate the production of "*Barbus*" from *Matsya*-like ancestors. If the presence or absence of a predorsal spine is ignored, *Barbus* and *Matsya* cannot be distinguished from each other by any other well-marked character. There would thus seem to be considerable justification for the views of Nichols and Pope[1]. and Nichols[2] to regard *Spinibarbus* as a subgenus of *Barbus*. In *B. kolus* Sykes (text-fig. 3 *d*) the neural spine in front of the dorsal fin are laminated in their basal halves and the laminae in some cases overlap one another. The dorsal lamellar ossicles are also well-developed for the attachment of the muscles.

In connection with the above hypothesis, it has also to be considered that *Barbus* is a much more widely distributed genus than the fishes of the *Rohtee* or the *Matsya* groups; it is undoubtedly of great antiquity, as it is found as far afield as Africa. It is possible, therefore, that *Barbus* represents the earliest descendants of the original migrating stock, while *Rohtee*, *Mystacoleucus*, *Matsya*, etc., represent the later waves of migration of a somewhat modified stock which have not been able to reach very distant regions owing to the land connections having disappeared in the meantime.

SUMMARY.

Matsya Day, with 5 branched rays in the anal fin, is recognised as a valid genus and to its synonymy are assigned *Spinibarbus* Oshima and *Spinibarbichthys* Oshima. On geographical grounds, however, species with a serrated dorsal spine are referred to *Matsya* (s. s.) and those with a smooth spine to *Spinibarbus* (subgenus of *Matsya*).

Mystacoleucus Günther, with 8-10 branched rays in the anal fin, is recognised as a valid genus. Owing to the presence of a predorsal spine in *Rohtee ogilbii* Sykes, it is referred to *Mystacoleucus*, the definition of which is emended to include forms with 14 branched rays in the anal fin.

Mystacoleucus, with a longer anal fin, is regarded as more primitive than *Matsya*.

[1] Nichols and Pope, *Bull. Amer. Mus. Nat. Hist.*, LIV, p. 343 (1927).
[2] Nichols, *ibid*, LVIII, p. 11 (1928).

The inter-relationships of *Rohtee* and *Parabramis* are discussed and the geographical distribution of all the forms referred to above is given. It is observed that the centre of distribution of these fishes has to be placed somewhere in South China whence at different periods different types of forms migrated both towards north and south. The northern forms retained their primitive features while, owing to the orogenic disturbances in South China and further south, the forms migrating towards south and those in the home-country became more highly specialised.

From a comparative study of the skeletal elements of the dorsal fin in 4 forms the probable mode of origin and function of the predorsal spine are given. It is concluded that *Barbus* was probably derived at a very early stage from *Matsya*-like ancestors.

NOTES ON FISHES IN THE INDIAN MUSEUM.

By SUNDER LAL HORA, *D. Sc., F. R. S. E., F. N. I., Assistant Superintendent, Zoological Survey of India, Calcutta.*

XXX.—ON THE SYSTEMATIC POSITION OF *CYPRINUS COSUATIS* HAMILTON.

Cyprinus cosuatis is one of the ten species assigned by Hamilton[1] to the eighth division—*Cabdio*—of the genus *Cyprinus* which comprises a very heterogenous assemblage of forms. The other species of this division are *C. jaya, C. mola, C. hoalius, C. borelio, C. solio, C. guganio, C. cotio, C. devario* and *C. dancena*. The generic name *Cabdio* is not in common use, but according to Jordan[2] its type should be the first species named, *i. e., Cyprinus jaya* Hamilton. In view of this limitation it is likely that *Aspidoparia* Heckel[3], with *A. sardina* as orthotype may have to be suppressed in favour of *Cabdio*. Of the other species, *C. mola* is usually assigned to the genus *Amblypharyngodon* Bleeker, *C. cosuatis* and *C. guganio* to *Barbus* Cuvier, *C. cotio* to *Rohtee* Sykes, *C. devario* to *Danio* Hamilton, while the precise generic and specific limits of the remaining species are still in doubt. Of the two small species at present included in the genus *Barbus, B. guganio* is known only from Hamilton's original description and figure and so far as I am aware no specimen of the species is at present available in any museum collection, though according to Hamilton (*loc. cit.*, p. 339) " The *Guganio* (*Gugani*) is probably found in most of the rivers and ponds of the Gangetic provinces, as I have seen it in both the Brahmaputra and Yamuna, the extreme rivers of that territory." Day[4] considered it to be a close ally of his *B. ambassis*, which he found in " Madras, Orissa, Bengal, and Assam at least as high as Suddya." *Barbus cosuatis* was originally described from the Kosi river, but Day extended its range to " Bengal through the N. W. Provinces, the Deccan and Bombay, and down the Western coast as low as Cottayam in Travancore."

Among other characters Hamilton (*loc. cit.*) noted the following distinguishing features of his *Cyprinus cosuatis*:

> " The *form* is deep, compressed, more prominent on the back than below. The *colour* is silver, with a greenish back, and the scales on the part are dotted towards the root. The ventral fins are red, all the others are yellowish, and those of the back and behind the vent are stained with black. The eyes are silver, stained above with black."

Day (*loc. cit.*) who figured a specimen of the species from Jubbulpore, noted that the fish attains 2 to 3 inches in length and directed attention

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[1] Hamilton, F.—*An Account of the Fishes found in the River Ganges and its branches*, pp. 333-343 (Edinburgh: 1822).

[2] Jordan, D. S.—*The Genera of Fishes*, p. 115 (Stanford University, California: 1917).

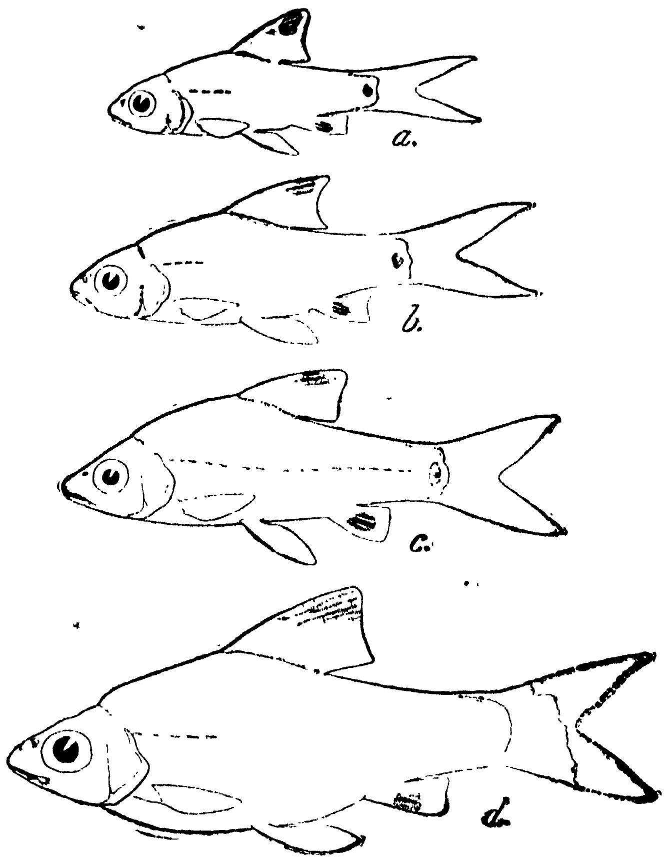
[3] Heckel, J. J.—Ichthyologie (von Syrien). In Russegger (Joseph von): Reisen in Europe, Asien und Africa, mit besonderer Rücksicht aufnaturwissen schaftlichen Verhältnisse der betreffenden Länder, unternommen in den Jahren 1835 bis 1841. Part 2, p. 288 (1877).

[4] Day, F.—*Fishes of India*, pp. 576, 579, 581 (1877).

to several of its salient features. Among these mention may be made of the following, (i) dorsal without any osseous ray, (ii) height of dorsal greater than depth of body, (iii) incomplete lateral line, (iv) scales along lateral line larger than others, (v) 8 or 9 rows of scales before base of dorsal and (vi) colouration. Recently in a specimen of the species from Mysore I[1] pointed out the greater extent of the lateral line and the well defined nature of the rounded black spots on the dorsal and the anal fins. Further it was observed that:

"The most remarkable feature of this species appears to be the presence of numerous, fine, parallel sensory folds on the sides of the head. This feature it shares with the fishes of the genus *Cyclocheilichthys* Bleeker, but in other respects it is quite different."

Later I found that Smith[2] had already described a new genus *Oreichthys* from Siam for Cyprinid fishes of the type of *Barbus cosuatis* and



TEXT-FIG. 1.—Outline drawings of the growth-stages of *Oreichthys cosuatis* (Ham.).
a. 18 mm. in length without caudal; *b*. 23 mm. in length without caudal; *c*. 26 mm. in length without caudal; *d*. 34 mm. in length without caudal.

[1] Hora, S. L.—Notes on Fishes in the Indian Museum, XXVIII. On three collections of Fish from Mysore and Coorg, South India. *Rec. Ind. Mus.*, XXXIX, pp. 17, 18 (1937).

[2] Smith, H. M.—Contributions to the Ichthyology of Siam, III. A New Genus and New Species of Cyprinoid Fishes. *Journ. Siam Soc., Nat. Hist. Suppl.*, IX, p. 63 (1933).

had assigned to it a new species *O. parvus*, which is said to grow to 31 mm. in total length. In general facies, lepidosis and colouration the Siamese fish seemed so similar to Hamilton's *cosuatis* that I requested Mr. Luang Choola, Officer-in-charge, Bureau of Fisheries, Bangkok, to send me for comparison a few specimens of Smith's species. He very kindly presented 3 examples of *O. parvus* to the Zoological Survey of India, and these have enabled me to come to a definite conclusion that *O. parvus* is a juvenile form of *Cyprinus cosuatis*. Further, it is clear that this species is sufficiently distinct, especially on account of the sensory folds on the head, from the numerous species of the genus *Barbus* known from India, and should, therefore, be retained in a separate genus *Oreichtys* Smith, which as pointed out by its author, is closely allied to *Cyclocheilichthys* Bleeker.

Oreichthys cosuatis (Ham.) is represented by a few specimens in the collection of the Indian Museum, and unfortunately most of them are not in a good state of preservation. The sensory folds on the head are, however, fairly distinct in all of them. A comparison with the young specimens from Siam shows that when the fish is about 18 mm. in length without the caudal fin (text-fig. 1 *a*.), the dorsal spine is longer than the head and the depth of the body, and the spot at the base of the caudal fin is intensely black. The spots on the dorsal and the anal fins are also well marked and seem quite compact. In a specimen about 23 mm. in length without the caudal (text-fig. 1 *b*) the depth of the body is almost equal to the length of the dorsal; the length of the head is considerably shorter than both these dimensions. The three colour spots are somewhat diffuse but more extensive. In a specimen from Mysore, about 26 mm. in length without the caudal (text-fig. 1 *c*), the depth of the body is considerably greater than the length of the dorsal fin, which is almost equal to the length of the head. The dorsal and the anal fin spots are well pronounced, while that at the base of the caudal fin is very diffuse and indistinctly marked. The most remarkable feature about this specimen is that the lateral line, though interrupted in places, extends up to the 20th scale. As a rule, it is present only on the first 4 or 5 scales. In a specimen from the Saran District of Bihar, about 34 mm. in length without the caudal (text-fig. 1 *d*), the length of the dorsal fin, though greater than that of the head, is considerably shorter than the depth of the body. The spot on the dorsal fin is very diffuse and extensive while that on the anal fin is only faintly marked. As far as I can make out from the spirit material, the spot at the base of the caudal fin is almost absent.

Though sufficient material is not available for a detailed study of the variations undergone by this fish with growth, it is clear from the above that the young specimens from Siam are referrable to Hamilton's species.

XXXI.—ON A SMALL COLLECTION OF FISH FROM SANDOWAY, LOWER BURMA.

In the course of an investigation of the Anopheline fauna of Sandoway, Lieut. E. S. Feegrade, Malariogist to the Public Health Department of Burma, collected several samples of fish from the stone-lined

shallow wells and the road-side drains of the town of Sandoway, headquarters of the district of the same name in Lower Burma and situated in Lat. 18° 28′ N. and Long. 94° 21′ E. The fish were collected in several lots between June and August 1936, and sent to the Zoological Survey of India for determination. At my request, Lieut. Feegrade arranged to have further specimens collected through Dr. U. Shwe Baw for the Zoological Survey of India. Though the entire material consists of 24 specimens only, two new species have been discovered. It has also been found that the specimens of the already known species vary considerably from their respective typical series, especially in colouration. These results are not surprising when it is remembered that the freshwater fish fauna of this region, including that of the neighbouring Arakan Yomas, has never been investigated before.

Lieut. Feegrade informed me that most of his material was collected in clear, running water, such as road-side drains, seepage water drains, small hill-streams and small ponds. It may be indicated that Sandoway is situated on the left bank of the Sandoway river, about 15 miles to the S. E. of its mouth and between 4 to 5 miles due east of the sea coast in a direct line. The area in its neighbourhood is full of tidal creeks and there is practically no plain land along the valley of the Sandoway river.

The following species of fish have been found in the collection :—

1. *Rasbora daniconius* (Ham.)	2 specimens.
2. *Brachydanio choprai* Hora	4 specimens.
3. *Danio feegradei*, sp. nov.	1 specimen.
4. *Barbus (Puntius) binduchitra*, sp. nov.	10 specimens.
5. *Barbus (Puntius) stoliczkanus* Day	5 specimens.
6. *Panchax panchax* (Ham.)	2 specimens.

I take this opportunity to offer my sincere thanks to Lieut. E. S. Feegrade for having made a valuable collection of fish for the Zoological Survey of India. The material is in a very good state of preservation.

Rasbora daniconius (Ham.).

1889. *Rasbora daniconius*, Day, *Faun. Brit. Ind. Fish.*, I, p. 336.

Rasbora daniconius is represented in Lieut. Feegrade's collection by two specimens, measuring 42 mm. and 45 mm. in total length. They were collected from a road-side drain. The black lateral band is very well marked and extends from the tip of the snout to the base of the caudal fin, the middle rays of which are stained gray. The scales above the lateral line, as also some below it, are marked with black dots along the margin. The dorsal surface is dusky with a black streak along the mid-dorsal line.

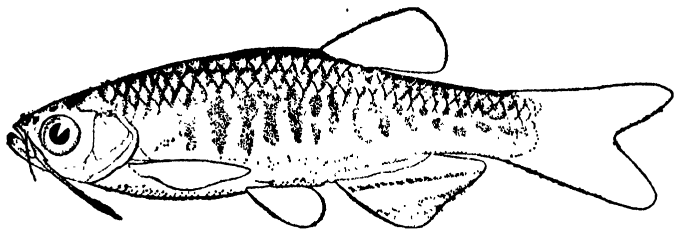
Brachydanio choprai[1] Hora.

1928. *Danio (Brachydanio) choprae*, Hora, *Rec. Ind. Mus.*, XXX, p. 39, fig. 2.
1934. *Danio (Brachydanio) choprae*, Hora & Mukerji, *Rec. Ind. Mus.*, XXXVI, p. 130 (Synoptic Table to species of *Brachydanio*).

There are 4 specimens of *Brachydanio choprai* from Sandoway; 2 were collected from a stone-well, while the remaining two were obtained

[1] By mistake *e* instead of *i* had been previously used in the termination of this specific name. The species was named after my colleague Dr. B. N. Chopra.

from a road-side drain. The two examples, 28 mm. and 30 mm. in total length respectively, from the well are more or less devoid of the typical colour pattern of the species, while those collected from the drain, 33 mm.



TEXT-FIG. 2.—Outline sketch of *Brachydanio choprai* Hora, showing colour markings in a specimen 33 mm. in total length.

and 36 mm. in total length respectively, are very gorgeously coloured. In the larger specimens the anterior vertical bands are replaced by rows of spots at the posterior end. The bands on the dorsal and the caudal fins are either faintly marked or are absent altogether. The band on the anal fin is, however, present in all the specimens.

There are several large sensory pores on the dorsal surface of the head along the supra-orbital edges. Though. as a rule, the lateral line is absent in this species, in certain specimens it may be present on the first few scales; when present, it bends abruptly downward and may extend as far as the base of the pelvic fin.

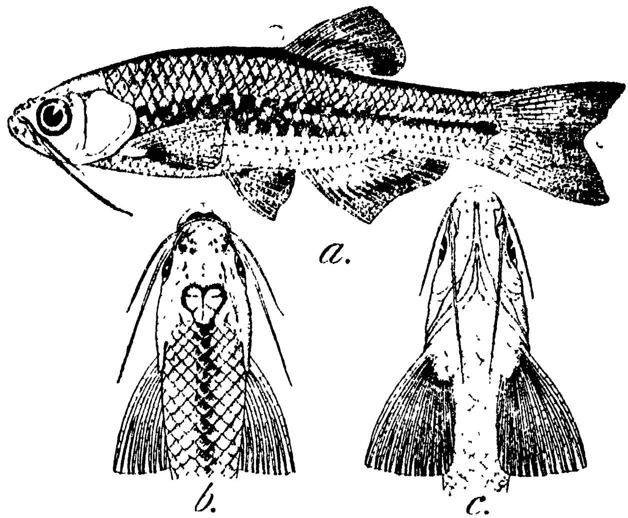
The species was hitherto known only from the Myitkyina District of Upper Burma.

Danio feegradei, sp. nov.

D. 2/9; A.3/12; P.12; V.8; C.19; L.1.39; L.tr.$7\frac{1}{2}/2\frac{1}{2}$.

The new species possesses a graceful form with both the dorsal and the ventral profiles slightly arched. The head and body are greatly compressed. The head is bluntly pointed and its length is contained 4·9 times in the total length and 3·9 times in the length without the caudal. The height of the head at the occiput is contained 1·3 times, and its width 1·8 times in its length. The diameter of the eye is contained about 3·3 times in the length of the head, 0·9 times in the length of the snout and 1·2 times in the interorbital distance. The nostrils are situated close to the anterior margin of the eye; the anterior nostril is somewhat tubular. Inner to the upper margin of the eye is a series of 4 large sensory pits similar to those described above in the case of *Brachydanio choprai*. Similar pores are also present on the ventral surface of the head. The mouth is small and oblique; it extends to below the anterior margin of the eye. The lips are thin, but are somewhat better developed near the angles of the mouth. Inner to the lower lip, on either side, there is a small pad of skin covered with spinous outgrowths. Presumably these structures represent the secondary sexual character of the male. There are two pairs of barbels; the rostrals are considerably shorter than the head, while the maxillary barbels are almost as long as the head or slightly longer. The basal portion of the rostral barbel is enclosed in a groove,

The depth of the body at the commencement of the dorsal fin is equal to the length of the head. The least height of the caudal peduncle



TEXT-FIG. 3. *Danio feegradei*, sp. nov.

a. Lateral view. × 1½; *b*. Dorsal surface of head and anterior part of body. × 2.

is contained 1.5 times in its length. The lateral line is complete and runs along the lower half of the caudal peduncle. There are about 39 rows of scales along the lateral line and 7½ rows between it and the base of the dorsal fin. There are 2½ rows of scales between the lateral line and the base of the pelvic fin which is provided with a scaly appendage. There are about 20 predorsal scales and 14 round the caudal peduncle. There are a few rows of small scales at the base of the anal fin.

The dorsal fin is short; its commencement is equidistant between the posterior margin of the eye and the base of the caudal fin; its height is considerably less than the depth of the body below it. The pectoral fin is smaller than the head and just reaches the base of the pelvic fin. The pelvic fin extends to the anal opening, but not to the anal fin. The anal fin is fairly extensive; the length of its base is equal to the head without the snout. The caudal fin is somewhat longer than the head, it is emarginate, with the upper lobe slightly longer than the lower.

The general ground colour, after preservation in spirit, is pale-olivaceous. The dorsal surface is dusky with a black streak along the mid-dorsal line. In the middle of the fish there is a black band which is considerably broader anteriorly and terminates posteriorly in a somewhat darker spot at the base of the caudal fin. Anteriorly the black band is marked, both above and below, with short pearl-white bands and in the posterior region there is a white longitudinal band above it. The rays of the dorsal and anal fins are marked with longitudinal bands across them.

Type-specimen.—F. 12477/1, Zoological Survey of India, Indian Museum, Calcutta.

Habitat.—Road-side drains, Sandoway, Lower Burma.

Remarks.—In referring this species to the genus *Danio* Hamilton a certain amount of difficulty has been experienced. Weber and de Beaufort[1] restricted this generic denomination to fishes with " Dorsal fin elongate, with 12-16 branched rays. Lateral line complete." The remaining species, " With dorsal fin short, with 7 branched rays only. Lateral line incomplete or absent.", were referred to *Brachydanio*. In 1934, Mukerji and the writer[2] observed that

> " During recent years several new forms of the *Brachydanio*-type have been discovered in Burma and though in all of them the dorsal fin is short, the lateral line has been found to be very variable. In the majority of forms it is either absent or extends over a few scales in the anterior region ; but there are some species in which it is fairly extensive or even complete."

Danio feegradi has only 9 branched rays, as against 7 in *Brachydanio* and 12-16 characteristic of the other species of *Danio*. In this respect it is intermediate between the two genera ; while in the possession of long barbels and a complete lateral line it shows greater affinities with the typical members of the *Danio* group. The colouration of this fish is quite different from other species of the genus known so far.

The name of this gorgeously coloured little fish is associated with that of Lieut. E. S. Feegrade.

Measurements in millimetres.

Total length excluding caudal	43·0
Length of head	11·0
Height of head at occiput	8·0
Width of head	6·0
Length of snout	3·0
Diameter of eye	3·3
Interorbital width	4·1
Height of body	11·0
Width of body	5·0
Longest ray of dorsal	8·3
Longest ray of anal	7·5
Length of pectoral	9·0
Length of caudal peduncle	9·0
Least height of caudal peduncle	6·0

Burbus (Puntius) binduchitra,[3] sp. nov.

D.3/8 ; A.3/5 ; P.16 ; V. 10 ; C.19 ; L.1.28-30 ; L.tr.5½/4½.

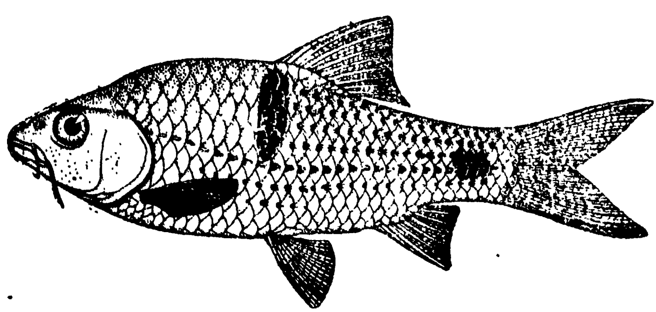
Puntius binduchitra is a small species in which both the dorsal and the ventral profiles are considerably arched. The body is greatly compressed ; the dorsal surface in front of the dorsal fin is more or less keeled. The head is bluntly pointed ; its length is contained from 4·5 to 4·7 times in the total length, and from 3·4 to 3·7 times in the length without the caudal. The height of the head at the occiput is contained from 1·1 to 1·2 times and its width from 1·3 to 1·6 times in its length. The head is proportionately smaller in the young specimens. The eye is lateral and situated close to the dorsal surface of the head ; its diameter is almost equal to the length of the snout and is contained from 2·6 (in the young) to 3·5 times in the length of the head ; usually it is contained from 3 to 3·5 times in the length of the head. The interorbital space

[1] Weber & de Beaufort, *Fish. Indo-Austral. Archipel.*, III, p. 85 (1916).
[2] Hora & Mukerji, *Rec. Ind. Mus.*, XXXVI, p. 130 (1934).
[3] *Binduchitra* is a combined Sanskrit word which means " spotted". In the specific name reference is made to the characteristic colouration of the species.

is flat and in the young specimens it is equal to the diameter of the eye ; in older specimens it is somewhat greater than the diameter of the eye. The nostrils are situated close to the front border of the eye and are separated by a flap of skin. The mouth is semicircular, almost inferior and sub-terminal. The lips are thin but continuous ; the labial groove is interrupted in the middle. There are two pairs of well developed barbels ; the rostral barbels are equal to the diameter of the eye, but the maxillary barbels are somewhat longer.

The depth of the body increases with growth ; it is contained from 3·6 to 4·4 times in the total length and from 2·8 to 3·4 times in the length without the caudal. The least height of the caudal peduncle is contained from 1·1 to 1·4 times in its length. The scales are large and firmly adherent ; there are from 28 to 30 series of scales along the lateral line, 5½ rows above it and 3½ rows below it to the base of the pelvic fin. The number of predorsal scales varies from 9 to 10. There are 14 scales round the caudal peduncle. The pelvic fin is provided with a scaly appendage at its base. The rows of scales at the bases of the dorsal and anal fin contain somewhat smaller scales and their shape is also different from those covering the other parts of the body.

The dorsal fin commences slightly in advance of the pelvics and somewhat nearer to the base of the caudal fin than to the tip of the snout ; its longest ray is usually shorter than the head. The last simple ray is articulated, but is serrated along the inner border. The anal fin is provided with 3 spines and 5 branched rays, the last of which is divided to the base. The pectoral fin is considerably shorter than the head and does not extend to the pelvic fin. The vent is situated just in front of the anal fin. The caudal fin is deeply forked ; both the lobes are pointed ; it is invariably longer than the head.



TEXT-FIG. 4.—Lateral view of the type-specimen of *Barbus* (*Puntius*) *binduchitra*, sp. nov. ×1¼.

The most characteristic feature of the species is its colouration. In all specimens there is a broad vertical band below the commencement of the dorsal fin which extends to the lateral line and a black blotch on the sides of the tail slightly in front of the base of the dorsal fin. In specimens over 56 mm. in total length, the scales above the lateral line and posterior to the large mark develop small rounded black spots in the centre so that the body in this region becomes spotted in a series of rows. Similar black spots appear on the scales of the lateral line and of those of the two rows below it, but they extend anteriorly beyond

the limit of the vertical mark. The upper edge of the dorsal and both the upper and lower margins of the caudal, especially the lower, become dusky in half-grown specimens and intensely black in somewhat older specimens.

Type-specimen.—F. 12478/1, Zoological Survey of India, Indian Museum, Calcutta.

Habitat.—Road-side drains and small streams at Sandoway, Lower Burma.

Remarks.—In its spotted colouration as well as in the possession of 4 well developed barbels and a serrated dorsal spine, *B. binduchitra* shows considerable affinity to *B. pinnauratus* (Day[1]) from South India and *B. sewelli* Prashad and Mukerji[2] from the Myitkyina District. In *B. sewelli* the body is considerably deeper (2·3 to 2·5 times in the length with the caudal in specimens over 90 mm. in length without the caudal), and there is always a large black blotch behind the gill-opening. Moreover, the vertical band and the caudal spot characteristic of the new species are lacking in *B. sewelli.* Both the species agree in having the dorsal surface in front of the dorsal fin keeled. *B. binduchitra* has greater affinity with *B. pinnauratus*, but its head is proportionately longer and not so high, the eye is relatively smaller, the interorbital width is less, the body is not so high but is relatively more compressed. Most of these differences seem to be correlated with the keeled nature of the dorsal surface in the new species; in *B. pinnauratus* the dorsal surface is flatly rounded. In *B. pinnauratus* there is a black band behind the gill-opening and in some specimens a short oval spot below the commencement of the dorsal fin[3]; it has hitherto been known "From fresh waters at Coconada down the east coast of India to Ceylon, and inland as far as the Neilgherries, also along the Western Ghats and rivers at their bases,"[4] but recently Mr. Duncan sent me very similar specimens from the Chindwin drainage near the border of Assam and Burma. Comments on his specimens are made below on p. 336.

Measurements in millimetres.

Total length including caudal	78·0	72·0	69·0	56·0	56·0	50·0	49·0	46·0	43·0	39·0	38·0
Length of caudal	18·5	15·3	16·0	12·5	12·3	12·0	11·5	11·0	10·3	9·0	9·0
Depth of body	20·2	20·0	18·8	15·0	15·0	13·0	12·3	10·5	10·0	9·0	8·5
Length of head	16·5	16·0	14·0	12·0	12·0	11·0	11·0	10·0	9·5	8·0	8·0
Height of head at occiput	13·3	13·0	12·5	11·0	11·0	9·0	9·0	8·0	7·5	7·0	7·0
Width of head	11·5	10·0	9·9	7·5	7·5	7·5	8·0	7·0	6·5	5·5	5·0
Length of snout	5·3	4·8	4·0	3·6	3·9	3·5	3·5	3·0	3·0	3·0	3·0
Diameter of eye	5·1	4·8	4·0	3·6	3·9	3·5	3·5	3·0	3·0	3·0	3·0
Interorbital width	5·7	5·0	4·8	4·3	4·5	4·0	4·0	3·5	3·3	3·0	3·0
Longest ray of dorsal	14·5	14·0	14·0	10·3	10·3	10·0	10·0	9·0	9·0	8·0	8·0
Longest ray of anal	10·0	10·0	10·0	7·5	8·0	7·0	7·0	6·5	6·3	5·0	5·0
Length of pectoral	12·0	12·0	11·3	8·5	9·0	7·3	7·3	6·8	6·5	6·0	6·0
Length of caudal peduncle	11·0	9·0	8·5	7·0	8·0	7·0	7·0	6·0	5·5	5·0	5·0
Least height of caudal peduncle	8·2	8·0	8·0	6·5	6·5	6·0	5·0	5·0	4·5	4·0	4·0

[1] Day, *Proc. Zool. Soc. London*, p. 300 (1865).
[2] Prashad & Mukerji, *Rec. Ind. Mus.*, XXXI, p. 197, pl. ix, fig. 1 (1929).
[3] Hora, *Rec. Ind. Mus.*, XXXIX, p. 9, fig. 1 (1937).
[4] Day, *Fish. India*, p. 562 (1877).

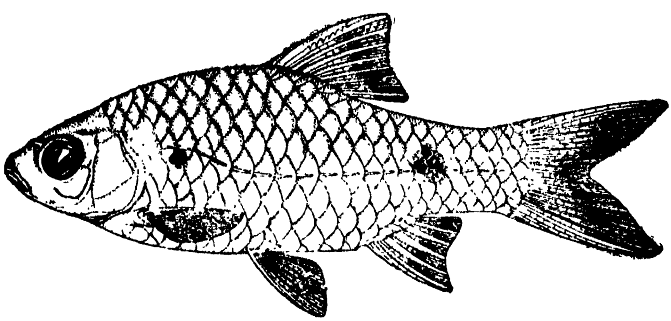
Barbus (Puntius) stoliczkanus Day.

1869. *Barbus M'clellandi,* Day (*nec* Cuvier & Valenciennes), *Proc. Zool. Soc. London*, p. 619.
1871. *Barbus* (*Puntius*) *Stoliczkanus,* Day, *Journ As. Soc. Bengal,* XL, pt. 2, p. 328.
1877. *Barbus stoliczkanus,* Day, *Fish. India,* p. 577, pl. cxliv, fig. 8.
1889. *Barbus stoliczkanus,* Day, *Faun. Brit. Ind., Fish.,* I, p. 326.
1893. *Barbus stoliczkanus,* Boulenger, *Ann. Mag. Nat. Hist.,* (6), XII, p. 202.
1918. *Barbus stoliczkanus,* Annandale, *Rec. Ind. Mus.,* XIV, p. 35.
1919. *Barbus stoliczkanus,* Chaudhuri, *Rec. Ind. Mus.,* XVI, p. 283.

Barbus stoliczkanus was originally described from a series of 21 specimens, 6 from Pegu and 15 from Moulmein, up to 4 inches in length. It was observed by Day that:--

"This species bears a strong resemblance to the *B. ticto*, H. B., which it appears to supersede in Eastern Burma. But it is distinguished by a complete instead of incomplete lateral line, and its body is not so compressed; its dorsal spine and colouring also differ."

The dorsal spine of this species is less strongly serrated than in *B. ticto,* while the position of the lateral spots is also different. The most important difference between the two species, however, lies in the number of the predorsal scales--8 to 9 in *B. stoliczkanus* and 11 in *B. ticto.* The



TEXT-FIG. 5.—Lateral view of a specimen of *Barbus* (*Puntius*) *stoliczkanus* Day. ×2½.

extent of the lateral line in the 5 specimens from Sandoway is variable; in two specimens it is almost complete, in two other specimens it extends over 17 to 19 scales while in one specimen it is limited to the first 7 scales. Sometimes the extent of the lateral line varies on the two sides of the same fish.

Day (1877) noted that "Some Darjeeling examples agree with the Burmese fish." Since Day's time, however, the species has been recorded only from Northern Burma (Boulenger: S. S. States; Chaudhuri: Putao). The Sandoway specimens are young, none exceeding 47 mm. in total length; they were collected from a road-side drain. In their proportions, lepidosis and number of fin rays, they agree with Day's description of the species, except in having a somewhat different colouration.

Measurements in millimetres.

Total length including caudal	47·0	42·0	41·0	40·0	37·0
Length of caudal	11·0	9·0	10·0	9·0	9·0
Length of head	8·0	7·0	7·0	7·0	7·0
Height of body	14·5	13·5	12·2	11·0	10·5
Diameter of eye	3·0	2·5	2·5	2·5	2·5
Length of snout	2·5	2·0	2·0	2·0	2·0
Interorbital distance	4·0	3·8	3·8	3·5	3·5
Commencement of dorsal from tip of snout	18·5	17·0	16·0	15·0	15·0
Longest ray of dorsal	9·5	8·0	8·0	8·0	8.0

Panchax panchax (Ham.).

1889. *Haplochilus panchax*, Day, *Faun. Brit. Ind. Fish.*, I, p. 417.

There are two specimens, about 44 mm. in total length, of *Panchax panchax* in the collection from Sandoway; they were collected from a road-side drain. *P. panchax* is a widely distributed species of the Oriental Region; its range extends from Orissa, through Lower Bengal, to Burma, Andaman Islands, Siam, Malay Peninsula and the Archipelago.

XXXII.—ON A SMALL COLLECTION OF FISH FROM THE UPPER CHINDWIN DRAINAGE.

At my request Mr. S. J. Duncan, Sub-Divisional Officer at Ukhrul, Manipur State, Assam, in the course of his tours made a small collection of fish for the Zoological Survey of India from the Upper Chindwin Drainage. As the area traversed by him is very close to the boundary between Assam and Burma, the material is of special interest for zoogeographical studies, and throws considerable light on the distribution of some of the species represented in the collection.

The material consists of 46 specimens which are referable to 12 species belonging to the families Cyprinidae, Cobitidae, Sisoridae and Ophicephalidae. These are listed below according to the localities from where the material was obtained.

1. Small stream below the village Singcha Tangkhul flowing into the Khunukong or Namballok (called Nampanga in Burma). 21.1.1937.

i. *Oreinus molesworthi* Chaudhuri . . . . 2 specimens.

2. Small stream below the village Chahong Khulen flowing into the Khunukong or Namballok. 25.1.1937.

i. *Barbus hexagonolepis* McClelland . . . . 1 specimen.
ii. *Barbus clavatus* McClelland . . . . . 1 specimen.

3. Upper reaches of the Namya river at Kongan Thana, a Kabo or Shan village. 28.1.1937.

i. *Barilius barila* Ham. . . . . . . 1 specimen.
ii. *Labeo devdevi* Hora . . . . . . 4 specimens.
iii. *Garra gotyla* (Gray) . . . . . . 4 specimens.
iv. *Barbus myitkyinae* Prashad & Mukerji . . 2 specimens.
v. *Nemachilus vinciguerrai* Hora . . . . . 7 specimens.
vi. *Glyptothorax trilineatus* Blyth . . . . 3 specimens.
vii. *Ophicephalus gachua* Ham. . . . . . 2 specimens.

4. Chakpi river at Chakpi Karong. 1.iii.1937.

i. *Barilius barila* Ham.	3 specimens.
ii. *Barbus pinnauratus* (Day)	3 specimens.
iii. *Barbus clavatus* var. *burtoni* Mukerji	2 specimens.

5. Lokchao river at Tamu. 15.iii.1937.

i. *Barbus pinnauratus* (Day)	5 specimens.
ii. *Lepidocephalichthys berdmorei* (Blyth)	6 specimens.

The range of distribution of the following species is extended in this article: *Barbus myitkyinae, B. pinnauratus* and *Glyptothorax trilineatus.* The most interesting record is that of *B. pinnauratus* which was hitherto known from South India only. It is also clear from the collection that the typical Burmese fauna is well represented in the Upper Chindwin Drainage.

I take this opportunity to record my sincere thanks to Mr. S. J. Duncan for the opportunity he has afforded me of examining fishes from a zoologically interesting region. The material is in an excellent state of preservation and forms a valuable addition to the collection of the Zoological Survey of India. Mr. Duncan's notes on the colouration of the species, reproduced below, are most helpful.

Family CYPRINIDAE.

Barilius barila Hamilton.

1921. *Barilius barila*, Hora, *Rec. Ind. Mus.*, XXII, p. 190.

Vernacular Names.—*Thēlbōl* Kuki; *Ngapāilā* Tangkhul; *Pakham* Kabo.

1 specimen. Namya river at Kongan Thana. 28.i.1937.
3 specimens. Chakpi river at Chakpi Karong. 1.iii.1937.

There are altogether 4 specimens of *Barilius barila* in the collection, ranging in length from 105 mm. to 120 mm. in total length. In none of the specimens the outer rays of the pectoral fins are specially strengthened for the purpose of adhesion to rocks. In all the specimens, particularly those from the Chakpi river, the body is covered with a number of black spots which represent encysted Trematode larvae; these should not to be confused with the colour markings. According to Mr. Duncan's observations the colouration is as follows:—

"Dorsal surface dark. Ventral white (or silvery). The sides are transversed by dark bluish broad stripes running parallel to each other. Fins pinkish."

B. barila is known both from India and Burma.

Oreinus molesworthi Chaudhuri.

1913. *Oreinus molesworthi*, Chaudhuri, *Rec. Ind. Mus.*, VIII, p. 247, pl. vii, figs. 2, 2*a*, 2*b*.

1935. *Oreinus molesworthi*, Hora & Mukerji, *Rec. Ind. Mus.*, XXXVII, p. 391.

Vernacular Names.—*Sana-nga* Manipuri; *Nganam* Kuki; *Khaingui* Tangkhul. The Manipuri name means "Goldfish".

2 specimens. Stream below Singcha Tangkhul. 21.i.1937.

Oreinus molesworthi is represented by 2 young specimens in the collection which are about 130 mm. and 142 mm. in total length

respectively. Though the specimens were collected only from one small stream below Singcha Tangkhul, Mr. Duncan states that " This fish is also found in other streams of the same drainage, but it is *not* found in all streams. It inhabits mostly the higher and colder reaches of the streams where they are found." It may be noted here that the type-specimen, 202 mm. in total length, was collected from Yembung at an altitude of 1,100 feet only.

Mukerji and I had recently extended the range of the species to the Chindwin drainage system in the Naga Hills.

According to Mr. Duncan the colouration of the species is as follows :—

" The dorsal surface is dark brown. This colour decreases in intensity as it approaches the dark thin line that runs right through the middle of the side from the angle of the operculum to the root of the caudal fin. When looked at laterally the colour appears steel grey. Below the dark line the colour is silvery white. The ventral surface is also white. The scales are very very small. Fins are slightly pinkish except perhaps the dorsal."

Labeo devdevi Hora.

1934. *Labeo (Labeo) dyocheilus* (in part), Mukerji (*nec* McClelland), *Journ. Bombay Nat. Hist. Soc.*, XXXVII, pp. 55-59 (Burmese and Siamese form, p. 58).

1936. *Labeo devdevi*, Hora, *Rec. Ind. Mus.*, XXXVIII, pp. 323-324.

Vernacular Names.—Ngatin Macha Manipuri ; *Ngachuntam* Kuki ; *Ngalu* Kabo.

4 specimens. Namya river at Kongan Thana. 28.i.1937.

In Mr. Duncan's collection *Labeo devdevi* is represented by 4 young specimens, varying in length from 83 mm. to 92 mm. in total length. Its superficial resemblance to *L. dero* (Ham.) is very great indeed ; but the two species can be readily distinguished by their lepidosis. Both *L. dero* and *L. devdevi* are liable to be confused with *L. dyocheilus* McClelland, but I have shown in the paper referred to above that McClelland's species has a very characteristic type of adhesive surface of the lower lip.

According to Mr. Duncan the colouration of the species is as follows :—

" Dark green dorsal surface and white ventral. The scales are small and have a coppery tint. Opercular region with a golden tint. Fins pinkish."

Garra gotyla (Gray).

1921. *Garra gotyla*, Hora, *Rec. Ind. Mus.*, XXII, p. 653.

1936. *Garra gotyla*, Hora & Mukerji, *Rec. Ind. Mus.*, XXXVIII, p. 144.

Vernacular Names.—Ngamu Sangkhom Manipuri ; *Ngapum* Kuki ; *Masangla* Tangkhul ; *Pachup-hen* Kabo.

4 specimens. Namya river at Kongan Thana. 28.i.1937.

Garra gotyla is perhaps the most widely distributed species of the genus, as it is found all along the Himalayas. The four specimens in Mr. Duncan's collection are from 97 mm. to 104 mm. in total length. The colour is almost black along the dorsal surface and the sides. Mr. Duncan found that " The whole body of the fish is dark green in colour except the ventral surface which is flattish and white." All the specimens are provided with a well developed proboscis on the snout.

In 1921, I[1] recorded *G. gotyla*, for the first time, from the north-eastern border of Burma and the Naga Hills.

Barbus hexagonolepis McClelland.

1936. *Barbus hexagonolepis*, Hora, *Rec. Ind. Mus.*, XXXVIII, p. 330.

Vernacular Names.—Ngara Manipuri; *Ngaha* Kuki.

1 specimen. Stream below Chahong Khulen. 25.i.1937.

In the paper referred to above I discussed the specific limits of the various species of the large-scaled Barbels found in Assam. It was also indicated that *B. hexagonolepis* is the commonest Barbel of the torrential streams of the Naga Hills. In Mr. Duncan's collection there is only one specimen, about 107 mm. in length without the caudal. Mr. Duncan states that it is the mighty *Mahseer* of this region and observes that it " is found in almost all the rivers in these hills ". His description of the colour is as follows :—

" Dark green dorsal surface. A white (sometimes yellowish) broad line runs laterally and below it another dark broad line runs in the same direction from the operculum to the root of the caudal fin. White ventral surface."

Barbus myitkyinae Prashad and Mukerji.

1929. *Barbus myitkyinae*, Prashad & Mukerji, *Rec. Ind. Mus.*, XXXI, p. 198, pl. ix, figs. 2, 2*a*, 2*b*.

Vernacular Names.—Ngasang Kuki; *Khaisang* Tangkhul; *Pachak* Kabo.

2 specimens. Namya river at Kongan Thana. 28.i.1937.

In Mr. Duncan's collection there are two specimens of *Barbus myitkyinae*, 97 mm. and 104 mm. in total length respectively. The species was described from the Myitkina District, Upper Burma, where it is stated to be quite common in the Indawgyi Lake and the streams in the adjacent area. The present record of *B. myitkyinae* from the Upper Chindwin Drainage shows that the species is probably widely distributed in the headwaters of the Chindwin and the Irrawadi rivers.

Barbus clavatus McClelland.

1921. *Barbus clavatus*, Hora, *Rec. Ind. Mus.*, XXII, p. 185, pl. ix, fig. 1.
1935. *Barbus clavatus*, Hora & Mukerji, *Rec. Ind. Mus.*, XXXVII, p. 388.

Vernacular Names.—Ngasang Kuki; *Khaisang* Tangkhul.

1 specimen. Stream below Chahong Khulen. 25.i.1937.

From the vernacular names and the notes supplied by Mr. Duncan it seems that the local people make no distinction between *Barbus clavatus* and *B. myitkyinae*. The two species are, however, abundantly distinct and can be readily distinguished by the relative length of the dorsal spine, which in the former is considerably longer than the head. The dorsal surface of *B. clavatus* in front of the dorsal fin is distinctly keeled.

Mr. Duncan notes that this fish is called, rightly or wrongly, the " White Mahseer ". ' Mahseer ' can only be used for this species in a

[1] Hora, *Rec. Ind. Mus.*, XXII, p. 743 (1921).

very loose sense, as it neither possesses large scales nor is its dorsal spine smooth. Moreover, the body of *B. clavatus* is considerably more compressed than that of the 'Mahseers'.

According to Mr. Duncan, the colouration of the species is as follows :—

"Dorsal surface dark green. Ventral surface white. The head or rather the opercular region golden tint. The whole body shows a slight golden tint when held up against the sun."

The only specimen of the species in Mr. Duncan's collection is about 112 mm. in total length.

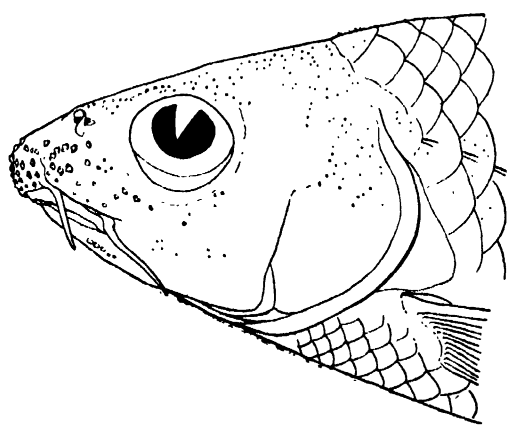
Barbus clavatus burtoni Mukerji.

1934. *Barbus clavatus burtoni*, Mukerji, *Journ. Bombay Nat. Hist. Soc.*, XXXVII, p. 64, pl. iii, fig. 1 and text-figures 10 & 11.

Vernacular Name.—*Ngasang* Kuki.

2 specimens. Chakpi river at Chakpi Karong. 1.iii.1937.

In describing *burtoni* as a subspecies of *Barbus clavatus*, Mukerji distinguished it from the typical form by its longer snout (greater than the diameter of the eye), shorter dorsal spine (less than the length of the head), lepidosis (small number of scales) and colouration (much darker, especially along the dorsal surface). In all these characters the two specimens in Mr. Duncan's collection, 132 mm. and 142 mm. in total length respectively, agree with the subspecies *burtoni*. The dorsal half



TEXT-FIG. 6.—Lateral view of head and anterior part of body of *Barbus clavatus* var. *burtoni* Mukerji, showing tubercular areas on the snout. ×2.

of the fish is intensely dark; the whole of the caudal fin is dusky and especially the lower lobe. The membranes in between the dorsal rays are black, except at the bases. The distal portion of the anal fin is grayish as also the dorsal surface of the pectoral fins. As in the typical form, the dorsal surface in front of the dorsal fin is distinctly keeled. In both the specimens the snout is provided with rows of well defined tubercles.

F

Although Kuki Nagas make no distinction between the typical form and the subspecies *burtoni*, Mr. Duncan distinguished them in the field by their different colouration.

Barbus pinnauratus (Day).

1877. *Barbus pinnauratus*, Day, *Fish. India*, p. 561, pl. cxxxix, fig. 3.
1937. *Barbus pinnauratus*, Hora, *Rec. Ind. Mus.*, XXXIX, p. 9, fig. 1.

Local Name.—Ngahao Manipuri.

3 specimens. Chakpi river at Chakpi Karong. 1.iii.1937.
5 specimens. Lokchao river at Tamu. 15.iii.1937.

According to Day, *Barbus pinnauratus* is found in " fresh waters at Coconada down the East coast of India to Ceylon, and inland as far as the Neilgherries, also along the Western Ghats and rivers at their bases". So far as I am aware[1] this species has not been found so far in any other part of India, and its present record from the Upper Chindwin is, therefore, of exceptional interest. Attention may here be directed to the similar distribution of *Danio strigillifer* Myers[2] which was originally described from Upper Burma but was recently recorded from South India.[3] To explain these and several other similar cases of a discontinuous range of distribution I[4] recently advanced a hypothesis. According to this view, when through a differential orogenic movement in the region of the present high peaks of the Himalayas (the region between the Assam and the Nepal Himalayas), the Himalayas were uplifted the migration of the aquatic fauna towards the Western Himalayas was checked and diverted along the Satpura trend of mountains to the Western Ghats whence it spread southward to the hills of the Peninsula. There is abundant evidence in favour of such a view both from the distribution of fishes and from the palaeogeographical features of the country during the Tertiaries.

The specimens in Mr. Duncan's collection agree very closely with those from South India, except that the spots on the scales are not so well defined and the head is relatively smaller. The younger specimens possess a black mark below the dorsal spine similar to the one recently described by me in the Tunga river specimens.

Sundara Raj[5] referred to the close similarity between *B. chrysopoma*, *B. pinnauratus* and *B. sarana*, all occurring in the Madras Presidency. To this complex of allied species may be added *B. caudimarginatus*, *B. oatesii*, *B. sewelli*, *B. mitkyinae*, *B. binduchitra* (a new species described above *vide* p. 327), etc., from Burma. In discussing the relationships of the new species I have already referred to the distinguishing features of *B. sewelli* and *B. pinnauratus*.

To bring out the close similarity in proportions, etc., between the South Indian and the Upper Chindwin specimens of *B. pinnauratus*

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[1] Karoli (*Term. füzetek*, V, p. 179, 1882) recorded *Barbus pinnauratus* by name only from Siam and Java. Weber and de Beaufort did not include this species in their work on the " Fishes of the Indo-Australian Archipelago ". Suvatti has, however, listed *B. pinnauratus* in his " Index to Fishes of Siam " on the authority of Karoli. Without further details it is not possible to be sure of Karoli's record.

[2] Myers, *Amer. Mus. Novitates*, No. 150, p. 1 (1924).

[3] Hora, *Rec. Ind. Mus.*, XXXIX, p. 10, fig. 3 (1937).

[4] Hora, *Rec. Ind. Mus.*, XXXIX, p. 255 (1937).

[5] Sundara Raj, *Rec. Ind. Mus.*, XII, p. 254 (1916); also see Annandale, *Rec. Ind. Mus.*, XIV, p. 46 (1918).

I give below a table of measurements of the specimens from the two regions.

Measurements in millimetres.

	Upper Chindwin.				Shimoga.	
Total length	83·0	90·0	103·0	116·0	83·0	92·0
Length of caudal	18·0	20·0	23·0	25·0	18·0	20·0
Length of head	15·0	16·0	17·2	21·5	16·0	19·0
Height of head	14·0	15·0	16·0	20·0	14·5	17·0
Width of head	11·0	12·2	13·0	16·1	12·0	13·0
Length of snout	4·0	5·0	5·0	6·0	5·0	5·0
Diameter of eye	6·0	6·5	6·5	7·0	6·1	6·8
Interorbital width	7·0	7·5	8·2	10·0	6·9	7·0
Height of body	23·0	26·0	27·0	32·0	24·0	25·0
Width of body	12·0	13·5	14·0	16·5	13·0	12·0
Longest ray of dorsal fin	14·0	17·0	21·0	23·0	15·0	18·0
Longest ray of anal fin	11·0	12·0	13·0	14·0	11·0	12·0
Length of pectoral fin	12·3	14·5	16·0	19·0	13·0	14·0
Length of caudal peduncle	12·0	13·0	13·5	16·0	12·0	13·0
Least height of caudal peduncle	9·0	10·0	11·0	13·0	9·0	10·0

Mr. Duncan made the following observations about the colouration of the species :—

" Dark dorsal and white ventral surface. In young specimens a biggish black spot, though not very prominent, on the body near the beginning of the caudal fin."

Family COBITIDAE.

Nemachilus vinciguerrai Hora.

1935. *Nemachilus vinciguerrae*, Hora, *Rec. Ind. Mus.*, XXXVII, p. 62, pl. iii, fig. 12.

Vernacular Names.—Ngajou Kuki; *Hangkorkhai* Tangkhul; *Pasulai* Kabo.

7 specimens. Namya river at Kongan Thana. 28.i.1937.

In Mr. Duncan's collection there are seven specimens of *Nemachilus vinciguerrai* ranging from 57 mm. to 76 mm. in total length. They agree fairly closely with the species recently described by me from Burma and Siam. Mr. Duncan's description of the colouration is as follows :—

" The general effect of the colouration scheme is a dirty biscuit colour, but the whole body is marked with transverse zebra stripes of light and dark alternately. The stripes are narrow in front of the dorsal and broader behind it as they approach towards the caudal fin. Fins have red edges."

In larger specimens the broader stripes behind the dorsal fin are stated to be alternately pink and dark.

Lepidocephalichthys berdmorei (Blyth).

1921. *Lepidocephalichthys berdmorei*, Hora, *Rec. Ind. Mus.*, XXII, p. 196.

Local Names.—Nga Krichou or *Nga Kachirou* Manipuri.

6 specimens. Lokchao river at Tamu. 15.iii.1937.

The specimens of *Lepidocephalichthys berdmorei* in Mr. Duncan's collection range from 46 mm. to 75 mm. in total length. In the smaller individuals the caudal fin is more markedly emarginate. Usually there

is a dark spot in the upper portion of the caudal fin near the base, but in the largest individual there is a well marked black ocellus in the same situation. This species is widely distributed in the Burmese waters.

Family SISORIDAE.

Glyptothorax trilineatus Blyth.

1923. *Glyptothorax trilineatus*, Hora, *Rec. Ind. Mus.*, XXV, p. 29.

Vernacular Names.—Monglheng Kuki; *Ngaprangla* Tangkhul; *Payahat* Kabo.

3 specimens. Namya river at Kongan Thana. 28.i.1937.

Glyptothorax trilineatus is represented by 3 specimens varying from 78 mm. to 87 mm. in total length. They possess the characteristic three white streaks and agree in every respect with Blyth's description of the species. Mr. Duncan observes that it is not a very common fish. The largest specimen he had ever caught was about 5 to 6 inches in length. The colouration of the living specimens is noted by him as follows :—

"Dark brown colour with a reddish tint. A light line runs laterally on both sides as well as along the dorsal profile. Fins very light red."

G. trilineatus is known from Tenasserim, Rangoon and Upper Burma. It is here recorded from the Chindwin Drainage for the first time.

Family OPHICEPHALIDAE.

Ophicephalus gachua Ham.

1935. *Ophicephalus gachua*, Hora & Mukerji, *Rec. Ind. Mus.*, p. 404.

Vernacular Names.—Ngamu Manipuri; *Ngavoh* Kuki; *Khaivā* Tangkhul.

2 specimens. Namya river at Kongan Thana. 28.i.1937.

In Mr. Duncan's collection there are two young specimens of *Ophicephalus gachua*; they are about 85 mm. in total length. The colouration of the species, according to Mr. Duncan's notes, is as follows :—

"Dark colour. White and greenish ventral. The body shows angular bands. The fins have half circles of light and dark."

XXXIII.—ON A COLLECTION OF FISH FROM THE KUMAON HIMALAYAS.

In May-June 1936, Mr. E. O. Shebbeare, Chief Conservator of Forests, and Mr. M. P. Bhola, Divisional Forest Officer, Haldwani Division, made a small collection of fish for me in the outer Himalayan hills below Naini Tal. The fish were obtained from the Nandhaur and Kalaunia rivers ; the former has its source in the Naini Tal District and flows over a bed of boulders. Within the hills its valley is narrow but broadens out in the plains. The fish were collected in the rocky portion of the stream. The Kalaunia river is similar to that of the Nandhaur river in its general physical features, but its source lies in the outer Himalayan hills of the Almora District. The fauna of the two streams is almost identical.

The entire collection comprises 207 specimens which belong to the following species.

MASTACEMBELIDAE.

Mastacembelus armatus (Lacép.)	1 specimen.

CYPRINIDAE.

Barilius bendelisis Ham.	24 specimens.
Barilius vagra Ham.	9 specimens.
Brachydanio rerio (Ham.)	7 specimens.
Labeo dero (Ham.)	9 specimens.
Garra gotyla (Gray)	8 specimens.
Garra prashadi Hora.	77 specimens.
Crossochilus latius (Ham.)	4 specimens.
Barbus putitora (Ham.)	17 specimens.
Barbus chilinoides McClelland	2 specimens.
Barbus conchonius (Ham.)	2 specimens.

COBITIDAE.

Nemachilus botia (Ham.)	13 specimens.
Nemachilus beavani Günther	22 specimens.
Lepidocephalichthys guntea (Ham.)	3 specimens.

SISORIDAE.

Glyptothorax pectinopterus (McClelland)	2 specimens.

ABLYCEPIDAE.

Amblyceps mangois (Ham.)	1 specimen.

OPHICEPHALIDAE.

Ophicephalus gachua Ham.	6 specimens.

The majority of the species listed above represent well known forms. Attention may, however, be directed to *Garra prashadi*, which was hitherto known from 3 specimens obtained in Malwa Tal; and to *Nemachilus beavani*, the precise specific limits of which were only recently defined by me from examples collected in the Eastern Himalayas. Notes on these two species are given below.

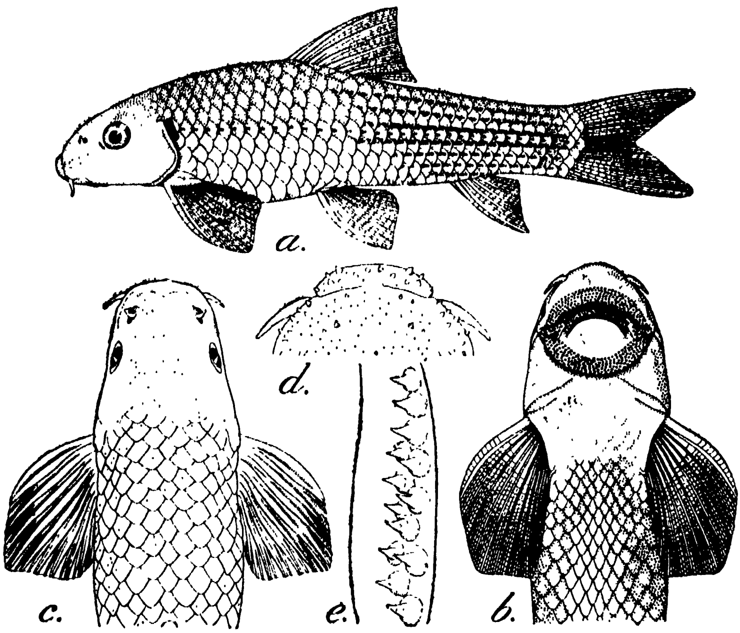
I take this opportunity to offer my sincere thanks to Messrs. E. O. Shebbeare and M. P. Bhola for their kindness in making a valuable collection of fish for the Zoological Survey of India.

Garra prashadi Hora.

1921. *Garra prashadi*, Hora, *Rec. Ind. Mus.*, XXII, p. 669, pl. xxiv, fig. 3.

As indicated above *Garra prashadi* was described from 3 specimens, of which 2 were males and 1 damaged female. Now a large series of 77 specimens has become available and it is possible to make some observations on the sexual dimorphism exhibited by the fish. In species of *Garra*, in which a well-developed proboscis is present on the snout, usually both the sexes are provided with 'pearl organs', etc.

In this respect I noted some sexual differences in the case of *G. lamta* and *G. gravelyi*. As regards the former species further material has shown (*vide infra*, p. 344) that I had grouped two distinct forms under *lamta*. The material of the latter species is not sufficient to elucidate this point.



TEXT-FIG. 7.—*Garra prashadi* Hora.

a. Lateral view of a female specimen. Nat. size; *b.* Ventral surface of head and anterior part of body of above. ×1½; *c.* Dorsal surface of head and anterior part of body of a male specimen. ×1½; *d.* Dorsal surface of snout of a female specimen. ×3½; *e.* Dorsal surface of a portion of one of the outer pectoral fin-rays of a male specimen showing the nature of horny tubercles. ×35.

In the female specimens of *G. prashadi* the tip of the snout is marked off by a shallow transverse groove and is covered with a few horny tubercles. A few horny tubercles are also present on the sides of the head in front of the eyes. In the males, however, the snout is smooth and there are only faint indications of two short lateral grooves which mark off the tip of the snout. The dorsal surface of the head in front of the eyes is slightly raised into two triangular patches; these areas are better marked in the female specimens. In the males the outer rays of the pectoral fins are provided with series of spines on the dorsal surface similar to those described by me[1] in the males of certain species of *Nemachilus*. As is usually the case, the body is relatively deeper in the females as compared with the males.

From the table of measurements given below, it will be seen that the head is relatively longer and the eye larger in young specimens. Other proportions also vary with growth to a limited extent.

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[1] Hora, *Rec. Ind. Mus.*, XXIV, p. 81 (1922).

Measurements in millimetres.

	♀				♂	
Total length including caudal	75·0	82·0	96·0	61·0	75·0	82·0
Length of caudal	16·0	17·1	21·0	14·0	16·0	17·1
Length of head	14·5	15·1	17·0	12·0	14·3	15·0
Width of head	12·0	12·5	14·1	10·0	11·3	12·0
Height of head at occiput	10·0	10·5	12·1	8·0	10·0	10·5
Height of body	16·0	16·5	21·0	11·0	15·0	15·5
Width of body	11·3	13·0	16·0	9·0	11·0	12·0
Length of snout	7·0	7·1	8·0	6·0	7·0	7·1
Diameter of eye	4·0	4·0	4·7	3·8	4·0	4·0
Interorbital width	7·0	7·0	8·0	6·0	7·0	7·1
Length of caudal peduncle	10·1	11·0	14·0	8·0	10·0	11·0
Least height of caudal peduncle	8·0	8·8	11·0	6·2	8·0	8·8
Longest ray of dorsal	15·0	15·0	18·5	12·0	15·2	15·3
Length of pectoral	14·0	15·0	18·0	12·1	15·0	16·0
Longest ray of anal	12·8	12·5	15·0	9·5	12·0	13·0

In *G. prashadi* the skin covering the anterior fin rays of the dorsal, the pectoral, the ventral, and the anal fins is produced into lappets which form a sort of a sheath for the following ray or rays. Such structures are characteristic of practically all torrential fishes and attention has already been directed to this feature by Smith and Deraniyagala. Their exact significance appears to be to provide a gliding surface for the current and thus minimise resistance. Their production seems to have been facilitated by the tearing away action of the current which would naturally pull an object in the direction of its flow.

Nemachilus beavani Günther.

1924. *Nemachilus* sp., Hora, *Rec. Ind. Mus.*, XXVI, p. 28, fig. 1.
1935. *Nemachilus beavani*, Hora, *Rec. Ind. Mus.*, XXXVII, p. 63.

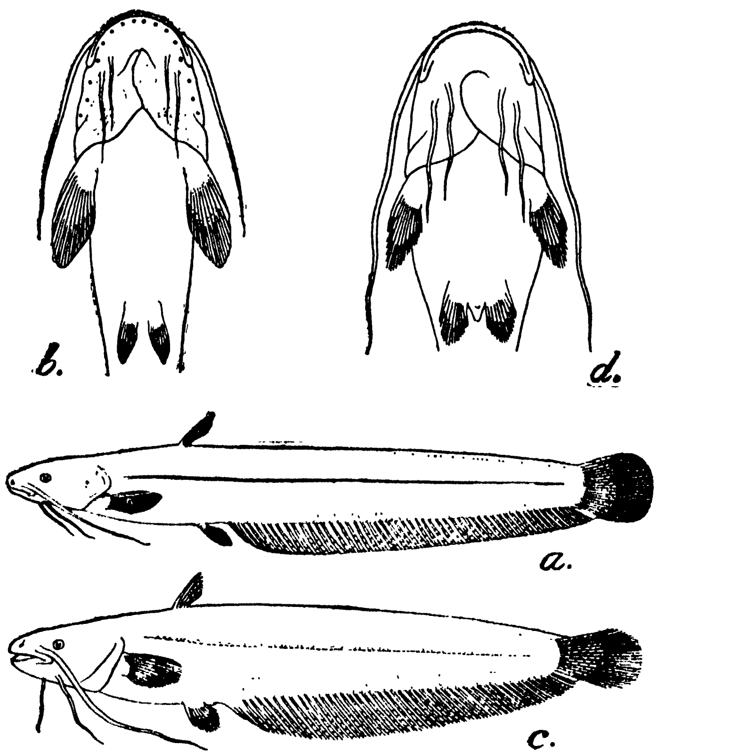
There are 22 examples in the collection under report which agree fairly closely with the Assamese and Eastern Himalayan specimens recently assigned by me to *Nemachilus beavani*. There are, however, variations in the number of bands and in the proportions of certain parts. It may here be noted that the species was originally described from the Kosi river and it is probable that the present lot represents the typical form of the species. I hope to deal with this point in my account of the species from the Western Himalayas.

XXXIV.—ON A NEW CATFISH FROM KWANGSI, CHINA.

In his 'Study on some Chinese Catfishes', Tchang[1] referred a specimen of *Silurus* Linn. from Lunchow in the Kwangsi Province, China, to Day's *S. wynaadensis*, which is known only from the Wynaad and Canara Hills in South India. At the same time he published a full description of the specimen along with two illustrations—a lateral view

[1] Tchang, *Bull. Fan Mem. Inst. Biol.*, VII, p. 35 (1936).

of the whole fish and a view of the ventral surface of the body in front of the anal fin. As I[1] had been working recently on the Indian species of *Silurus*, this interesting record attracted my attention and I requested Mr. T. L. Tchang to lend me the specimen of his *S. wynaadensis* for comparison with the typical examples of the species in the collection of the Zoological Survey of India, but he regretted his inability to comply with my request. Fortunately his description and figures are sufficiently detailed to enable me to institute a comparison between his form and the typical examples.



TEXT-FIG. 8.—*Silurus wynaadensis* Day and *S. sinensis*, sp. nov.

a. Lateral view of *Silurus wynaadensis* Day. × *ca* $\frac{4}{5}$; *b.* Ventral surface of head and anterior part of body of *S. wynaadensis* Day. × $1\frac{1}{3}$; *c.* Lateral view of *S. sinensis*, sp. nov. *ca* $\frac{3}{5}$; *d.* Ventral surface of head and anterior part of body of *S. sinensis*, sp. nov. *ca* $1\frac{1}{3}$.

Figs. *c.* and *d.* are copied from Dr. T. L. Tchang's drawings.

In the Indian specimens the dorsal fin is entirely in advance of the ventrals, the pectorals are separated from the ventrals by a considerable distance and the maxillary barbels do not extend beyond the pectoral fin. In the specimen from Kwangsi a portion of the dorsal fin is situated above the bases of the ventrals, the pectorals almost extend to the bases of the ventrals and the maxillary barbels extend beyond the

[1] Hora, *Rec. Ind. Mus.*, XXXVIII, pp. 351-356 (1936).

commencement of the anal fin. A comparative table of proportions of the various parts is given below :—

	Kwangsi.	Wynaad.		Canara.
Length to base of caudal	90 mm.	100 mm.	122 mm.	123 mm.
Depth in length without caudal	6·0	9·1	8·1	7·3
Head in length without caudal	4·7	5·4	5·5	5·6
Eye in head	8·0	9·2	7·3	7·3
Interorbital distance in head	1·9	2·5	2·2	2·2
Snout in head	2·4	3·1	3·0	3·0
Outer Mandibular barbel in head	1·2	1·8	1·8	1·8
Inner Mandibular barbel in head	1·3	1·9	2·0	2·0
Longest dorsal ray in head	2·1	2·5	2·4	2·6
Pectoral in head	1·5	1·5	1·7	1·7
Ventral in head	2·5	3·0	3·1	3·1

It is clear from the above table that in the Chinese example the body is considerably deeper, the head is longer, the interorbital space wider, the snout longer and all the barbels much better developed than those in the Indian examples. On account of the differences noted above and also on geographical grounds it is necessary to regard Tchang's specimen of *S. wynaadensis* as representing a new species which I propose to name **Silurus sinensis.** For a description of the species reference may be made to Tchang's account. His illustrations are reproduced here along with fresh drawings of a typical specimen of *S. wynaadensis* for comparison.

The occurrence of a true *Silurus*, with 4 mandibular barbels, in South China is of special significance. Hitherto only two species of the genus, in its restricted sense, were known, *S. glanis* Linn. from Europe (east of the Rhine) and *S. wynaadensis* Day from South India. Among the species, which are usually included in the genus *Parasilurus* on account of having only two mandibular barbels, we have two very widely distributed species, one in the north, *Parasilurus asotus* (Linn.) known from Japan, China and Eastern Russia, and the other in the south, *P. cochinchinensis* (Cuv. & Val.), found in Formosa, South China, Cochin-China, Mergui Archipelago, Burma, and Eastern Himalayas. The remaining species of the group, *P. cinereus* (Dabry), *P. grahami* (Regan) and *P. mento* (Regan), are found only in Yunnan. It has been found that very young specimens of *Parasilurus asotus* are provided with 2 pairs of mandibular barbels[1] which shows that *Silurus* (s.s.) certainly represents a more primitive type of fish.

From the distributional records given above it is clear that the largest number of species of the genus *Silurus* are found in South China. In fact, all the species, with the exception of *S. glanis* and *S. wynaadensis*, have been found in this region. *S. glanis* and *S. wynaadensis* are characterised by 4 mandibular barbels and, therefore, represent the earliest stock of the genus which is now pushed out into very great distances from the original centre of the distribution of the genus. *Silurus sinensis* should, according to this view, represent a part of the original stock in the home country of the genus.

[1] Atoda, *Dolutsugaku rasshi*, XLVII, p 228 (1935); Kimura, *Journ. Shanghai Sci., Inst.* Sec. 3, III, p. 105 (1935).

XXXV.—A FURTHER NOTE ON HAMILTON'S *CYPRINUS (GARRA) LAMTA*.

In my[1] revision of the fishes of the genus *Garra* it was indicated that the type-locality of Hamilton's[2] *Cyprinus lamta* had to be located in "small streams among rocks south of Monghir" whence he obtained his specimens of *Godyari*, also called *Sahari*. It was further pointed out that in the 'rocks south of Monghir' reference was probably made to the well-known Kharagpur Hills in the present-day district of Monghir. To elucidate the precise specific limits of the species, topotypes were obtained, but unfortunately I was only able to secure very young specimens, less than 50 mm. in total length. Among the material thus obtained two distinct types were recognised, one with a short central proboscis on the snout and the other without a proboscis. It was then presumed that the former represented the male and the latter the female of the same species. The characters of *G. lamta*, based on juvenile specimens, were, however, not found sufficiently distinctive by Prashad and Mukerji[3] and Mukerji[4], who referred certain examples from Burma to *Garra lamta*. It thus seemed clear that only mature specimens of *G. lamta* could enable a proper appreciation of the species.

In February 1937, I came to know that Mr. A. Das, a botanist and a keen naturalist, was touring in the Kharagpur Hills. A request was made to him to collect specimens of the local fish *Godyari* and sufficient details were sent for the recognition of the species. In March, I received 10 specimens of the desired type with a small miscellaneous lot. Mr. Das, like myself, found that *Garra* is known as *Patharchata*, stone-licking fish, in the Bhimband locality, Kharagpur Hills. The specimens, from 36 mm. to 67 mm. in length without the caudal, were collected from the Man river. The material contains the adult examples of both the sexes, so it is now possible to give a detailed description of the species and to remove a certain amount of confusion from the taxonomy of the genus.

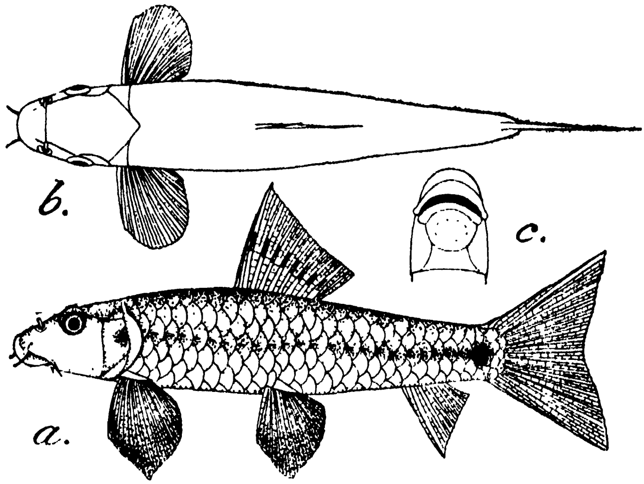
Hamilton's description of *G. lamta* is of a very generalised type, but attention may be directed to the following salient features as noted by him :—

1. Pectoral fins sharp in the middle.
2. Grows to about three inches in length.
3. A faint spot on each side towards the end of the tail.
4. Dorsal fin before the middle.
5. Pectoral fins nearly as long as the head.

In the manuscript drawing of the species there is an indication of a lateral band about the level of the lateral line which terminates behind in the precaudal spot and extends forwards to the gill-opening. The

[1] Hora, *Rec. Ind. Mus.*, XXII, pp. 633-687, pls. xxiv-xxvi (1921).
[2] Hamilton, *Fish. Ganges*, pp. 343, 393 (Edinburg : 1822).
[3] Prashad & Mukerji, *Rec. Ind. Mus.*, XXXI, p. 192 (1929).
[4] Mukerji, *Journ. Bombay Nat. Hist. Soc.*, XXXVII, p. 48 (1934).

fins are grayish with the middle portions of the inter-radial membranes of the dorsal fin marked with black spots.



TEXT-FIG. 9.—Copies of Francis Hamilton's manuscript drawings of *Cyprinus* (*Garra*) *lamta*.

a. Lateral view finished in colour in the original; *b.* Outline sketch of dorsal view; *c.* Ventral surface of head, finished in pencil in the original.

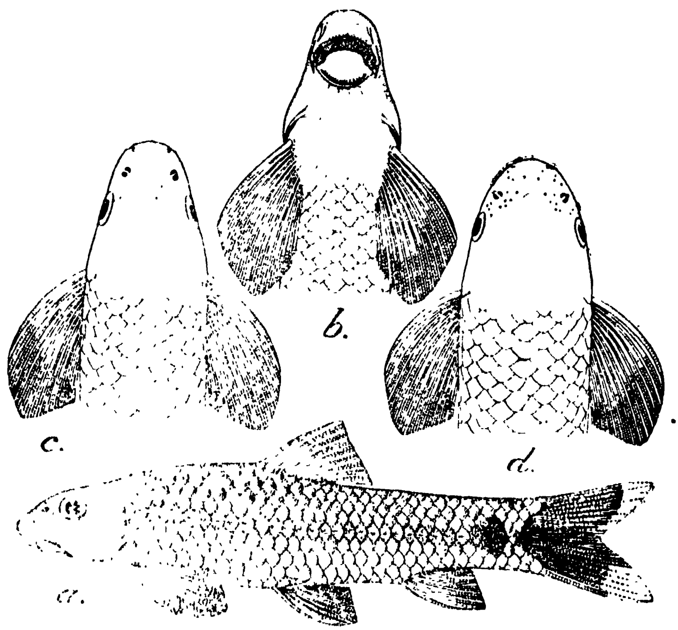
Judging from the characters noted above, there seems no doubt that the material sent by Mr. Das is definitely referrable to *G. lamta* which may now be defined as follows :—

Garra lamta Hamilton.

1822. *Cyprinus* (*Garra*) *lamta*, Hamilton, *Fish. Ganges*, pp. 343, 393.
1838. *Gonorhynchus lamta*, McClelland, *As. Res.*, XIX, p. 282, pl. cliii, fig. 2.
1921. *Garra lamta*, Hora, *Rec. Ind. Mus.*, XXII, p. 660.

Garra lamta is a small species in which both the dorsal and the ventral profiles are somewhat arched. The head and the anterior part of the body are flattened. The head is small, broad and broadly rounded in front; its length is contained from 4·3 to 4·6 times in the total length and from 4·1 to 4·5 times in the length without the caudal. The head is proportionately longer in younger specimens. The head is relatively narrower in the smaller individuals; its width is contained from 1·2 to 1·4 times and its height at occiput about 1·3 times in its length. The eye is situated near the dorsal profile of the head and in adult males it is almost in the middle of the head while in females it is nearer to the posterior margin of the operculum than to the tip of the snout. The snout is considerably broader in the females than in the males. The diameter of the eye is contained from 2·5 (in the young) to 3·5 times in the length of the head. In young specimens the diameter of the eye is greater than the length of the snout, but in adults it is about two-thirds of the same dimension. The interorbital distance is only slightly greater than the diameter of the eye in young specimens but with growth it almost becomes double the eye diameter. In the adult

females the interorbital space is somewhat greater than that in the males. The tip of the snout is marked off by two short lateral grooves. There is no proboscis but a few horny tubercles are usually present. The mental disc is relatively small.



TEXT-FIG. 10.—*Garra lamta* Hamilton (Specimen from the Kharagpur Hills, Bihar).
a. Lateral view of a male specimen. Nat. size; *b.* Ventral surface of head and anterior part of body of a male specimen. ×1⅓; *c.* Dorsal surface of head and anterior part of body of a male specimen. ×1⅓; *d.* Dorsal surface of head and anterior part of body of a female specimen. ×1⅓.

The depth of the body varies from 4 to 5·2 times in the total length and from 3·7 to 4·1 times in the length without the caudal. The caudal peduncle is only slightly longer than its height. The body is covered with firmly-set scales which are only faintly marked in the chest region. There are about 32-34 scales along the lateral line and 3½ rows below it to the base of the ventral fins. The rows of scales between the lateral line and base of the dorsal fin varies from 4½ to 5½. The number of predorsal scales is 12. The ventral fin is provided with a scaly appendage at its base.

The dorsal fin commences slightly in advance of the ventrals; its commencement is nearer the tip of the snout than the base of the caudal fin. The longest ray of the dorsal fin is somewhat longer than the head in young specimens and shorter in adults. The pectoral fin is slightly longer than the head and is separated from the ventrals by a considerable distance. The ventrals are considerably nearer the base of the caudal than the tip of the snout; they just extend to the anal opening. The distance between the vent and the base of the anal fin is less than one-third the distance between the commencements of the anal and ventral fins.

The most characteristic feature of the species is its colouration. There is a broad lateral band from behind the gill-openings to the base of the caudal fin where it ends in a rounded spot. It is bordered, both above and below, by light pale stripes. The dorsal surface is grayish and each scale is marked with a dense black dot in the centre of the posterior margin. These black spots form longitudinal stripes. A black spot near the upper angle of the gill-opening is present and the membranes between the dorsal spines, especially near the base, are marked with dark spots. The lateral surface below the lateral line is dusky and so are the dorsal and the caudal fins.

The lateral band and the precaudal spot should enable this species to be readily distinguished.

Measurements in millimetres.

							♂	♂	♀
Total length without caudal . . .	36·0	39·0	45·0	46·0	49·0	51·0	58	65	67
Length of head . .	8·8	9·0	11·0	11·2	11·7	12·0	13·0	14·3	15·0
Width of head . .	6·3	7·0	8·0	9·0	9·2	9·3	10·1	12·0	12·1
Height of head at occiput	7·0	7·3	8·0	8·2	8·5	9·0	10·0	10·5	11·0
Height of body . .	9·0	10·5	11·0	12·2	13·0	13·0	15·0	17·0	17·0
Length of snout . .	3·1	3·0	4·3	4·7	4·9	4·8	5·0	6·0	6·0
Diameter of eye . .	3·5	3·5	4·0	3·9	4·0	4·0	4·25	4·25	4·3
Interorbital width . .	3·9	4·0	5·0	5·0	5·5	6·0	6·0	7·0	7·5
Longest ray of dorsal .	9·0	9·0	11·5	11·2	12·0	13·0	13·7	14·0	13·0
Longest ray of anal . .	7·3	7·5	7·5	8·0	9·0	10·0	11·5	11·0	11·0
Length of pectoral . .	10·0	10·0	11·0	11·2	12·5	14·5	14·5	16·0	15·4
Length of caudal peduncle	5·7	5·8	7·5	8·0	8·0	9·0	9·0	11·0	11·0
Least height of caudal peduncle . . .	5·0	5·0	6·2	6·9	7·0	8·0	8·0	9·0	9·5

Remarks.—From the above it is clear that the small specimens with a median proboscis on the snout, which I[1] had regarded to be the males of this species, do not belong to *G. lamta*. They seem to be similar to the young specimens of *G. gotyla*, which Mukerji and I[2] collected in the Eastern Doons. It was observed by us that " The proboscis is present in both the sexes and even in young specimens, about 53 mm. in total length, it is fairly prominent."

The young specimen recorded by Prashad and Mukerji[3] from the Sankha hill-stream in the Myitkyina District, Upper Burma, as *G. lamta* belongs to *G. gotyla*, as also the specimen reported upon by Mukerji[4] from the Mali Hka river. The last specimen is undoubtedly similar to the form recorded by Vinciguerra[5] as *G. lamta*, but a detailed study of the specimens has shown that they belong to *G. gotyla*. The proboscis is broad and massive in these specimens and is anteriorly lobed

[1] Among the specimens I had referred to *G. lamta* in 1921, I find that there are only four, 1 from the Man river and 3 from the Katin nallah, which belong to this species while all the others are young of *G. gotyla*.

[2] Hora & Mukerji, *Rec. Ind. Mus.*, XXXVIII, p. 144 (1936).

[3] Prashad & Mukerji, *Rec. Ind. Mus.*, XXXI, p. 192 (1929).

[4] Mukerji, *Journ. Bombay Nat. Hist. Soc.*, XXXVII, p. 48 (1934).

[5] Vinciguerra, *Ann. Mus. Civ. Stor. Nat. Genova* (2), IX, p. 275 (1890).

by the presence of the hard, horny tubercles. In the Indian specimens of *G. gotyla* the proboscis is narrower and projects forward as a short cylinder. It is probable that when further material becomes available from Burma it may have to be regarded as a separate species, but in the present state of our knowledge such a course is not justified. *G. gotyla* is known from the Chindwin and Irrawadi drainage systems (*vide supra*, p. 333); its range extends all along the Himalayas. Deraniyagala[1] found a closely allied form in Ceylon and in commenting on its relationships I observed (*vide* Deraniyagala, *op. cit.*): "The Ceylonese *G. gotyla*, if I may use this phrase, seems to have evolved the characters of the species independently, so that these two forms are the results of a parallel evolution." In view of certain palaeogeographical considerations[2] I now find that at a certain period the fauna of the Himalayas probably spread along the Satpura trend to the Western Ghats and thence to the hills of the Peninsula and Ceylon. The record of the young specimens of *G. gotyla* from the eastern section of the Vindhyan Range is, therefore, of special significance in this connection. The antiquity of *G. gotyla* is also evident from the fact that, according to Deraniyagala, the young of *G. ceylonensis ceylonensis*, the commonest form of *Garra* in the island, often show the characters of *G. gotyla*.

From the above observations it may be concluded that *G. lamta* is known so far only from the Kharagpur Hills for it is likely that the Rapti river form (Gorakhpore Dist.) may prove to be quite different.

XXXVI.—ON A NEW GENUS OF CHINESE CATFISHES ALLIED TO *PSEUDECHENEIS* BLYTH[3].

In his "Study on some Chinese Catfishes", Tchang[4] recorded *Pseudecheneis sulcatus* (McClelland)[5] from China and very fortunately gave a description and two figures of the single specimen obtained in Yunnan and now preserved in the Zoological Museum of Fan Memorial Institute of Biology, Peiping (No. 12016). The description and figures are so different from those of the form known to me from India and Burma that I wrote to Dr. Tchang for a loan of the interesting specimen for comparison with the numerous topotypes of the species in the collection of the Zoological Survey of India, but in reply he expressed his inability to accede to my request. The Yunnanese example, however, seems to be so different from the Indian species that I have no hesitation in suggesting for it a separate genus **Propseudecheneis** and to christen the species, after the name of its discoverer Dr. T. L. Tchang, **Propseudecheneis tchangi,** sp. nov.

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[1] Deraniyagala, *Ceylon Journ. Sci.* (B), XVII, p. 227 (1933).

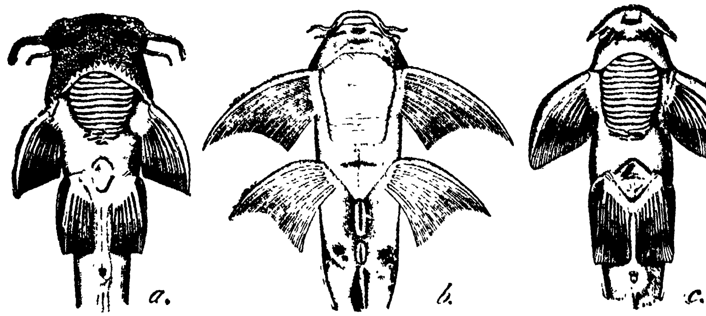
[2] Hora, *Rec. Ind. Mus.*, XXXIX, p. 255 (1937).

[3] The article along with a specimen of *Pseudecheneis sulcatus* (McClelland) was sent in April 1937 to Dr. T. L. Tchang for his comments and its subsequent publication in the Bulletin of the Fan Memorial Institute of Biology. No reply has yet been received and owing to the Sino-Japanese war its publication in China now seems doubtful.

[4] Tchang, *Bull. Fan Memorial Inst. Biol.* (Zool.), VII, p. 47 (1936).

[5] McClelland, *Calcutta Journ. Nat. Hist.*, II, p. 584 (1842).

Propseudecheneis can be readily distinguished from *Pseudecheneis* Blyth[1] and *Parapseudecheneis*[2] by the nature of its mouth, lips and



TEXT-FIG. 11.—Ventral surface of head and anterior part of body of *Parapseudecheneis* Hora, *Propseudecheneis*, gen. nov., and *Pseudecheneis* Blyth.

a. Parapseudecheneis paviei (Vaillant); *Propseudecheneis tchangi*, gen. *et* sp. nov.; *Pseudecheneis sulcatus* (McClelland).

Figure *b.* is copied from Dr. T. L. Tchang's drawing.

jaws and also by the form and position of its paired fins. The general build of the body is also different in the three genera. Some of their distinguishing features are tabulated below :—

Propseudecheneis, *gen. nov.*	*Pseudecheneis* Blyth.	*Parapseudecheneis* Hora.
Head and body greatly depressed; head considerably narrower anteriorly with the apex truncate.	Head and body subcylindrical; head broadly rounded anteriorly.	Head and body greatly depressed; head broad and almost truncate anteriorly.
Mouth small, inferior, transverse; lips thick, with small papillae.	Mouth very small considerably behind tip of snout; lips thick, reflected round the mouth and studded with papillae.	Mouth somewhat extensive, sub-inferior; transverse; lips thick and corrugated.
Adhesive disc composed of 21 folds which are probably faintly marked.	Adhesive disc composed of 14-15 prominent folds.	Adhesive disc composed of 10-11 prominent folds.
Outer ventral ray the longest; probably not provided with adhesive folds on ventral surface.	Outer ventral ray short, broad and provided with adhesive folds on ventral surface.	Outer ventral ray short, broad and provided with adhesive folds on ventral surface.

Tchang's description of the unique specimen of *Propseudecheneis* is not sufficiently detailed to institute any further comparison with the other two allied genera, but the figures of the ventral surface of the head and the anterior part of the body of the type-species of *Pseudecheneis* *Parapseudecheneis* and *Propseudecheneis* reproduced here clearly show their principal distinguishing features.

In 1930, I (*op. cit.*, p. 217) regarded *Pseudecheneis* and *Parapseudecheneis* as having been evolved independently under the influence of

[1] Blyth, *Journ. As. Soc. Bengal*, XXIX, p. 154 (1860).
[2] Hora, *Rec. Ind. Mus.*, XXXIII, p. 215 (1930).

some similar factor or factors in their environment, but recently, when I[1] became aware of the probable changes in the drainage system of South-eastern Asia, I considered them to be genetically related. The discovery of the Chinese form lends considerable support to the latter view. Judging from the structure of the three genera, it seems probable that *Propseudecheneis* represents the generalised form and that the other two genera are derived from it under somewhat different sets of environmental conditions. *Parapseudecheneis* appears to have been evolved in somewhat deeper rocky streams with fast currents, such as are now found in the plateau of Central Asia where somewhat similar forms of *Glyptosternum* McClelland, but without the thoracic adhesive apparatus, such as *G. maculatum* (Regan) in Eastern Tibet and *G. reticulatum* McClelland in Eastern Turkestan, Chitral, Afghanistan, Kashmir, etc., are found today. *Pseudecheneis* seems to be specially adapted to live in turbulent waters of small rocky streams of the south-eastern slopes of the Himalayas and the connected chain of hills. I have indicated in several of my earlier works that the " transfer of the adhesive organ from the centre of the animal to the extremities is a remarkable feature of all the hill-stream animals."[2] Such a transfer is well illustrated in the case of the species of *Glyptothorax* Blyth, where in the less specialised forms the adhesive folds are very extensive in the thoracic region but are totally absent from the paired fins. In the highly specialised forms, such as *G. striatus* (McClelland) and *G. pectinopterus* (McClelland), on the other hand, the thoracic apparatus is greatly reduced while the outer rays of the paired fins are provided with adhesive pads. Judging by this criterion alone, *Propseudecheneis* would seem to be the most generalised form, which gave rise to *Pseudecheneis* in India and to *Parapseudecheneis* in Indo-China. *Parapseudecheneis* probably gave rise to *Glyptosternum*-like fishes while the other two genera seem to be the progenitors of a variety of Glyptosernoid fishes found in China, Siam, Burma and India.

It seems to be the case with practically all the present-day freshwater genera of Indian fishes that their ancestral home was in South China or in the case of the mud-loving forms Indo-Chinese region. From these regions the aquatic fauna spread towards the south and west, and the subsequent changes in their environment induced the evolution of a great variety of genera, especially in the regions of the Himalayan upheavals.

Propseudecheneis is found in Yunnan, *Parapseudecheneis* in Tongking and *Pseudecheneis* in Nothern Burma, Assam and the Eastern Himalayas (Brahmaputra Drainage System). The first two genera are thus found in the Red River System, which according to Gregory[3] was once a mighty stream as it comprised the headwaters of the Yangtse-Kiang. The ancestral form of *Pseudecheneis* was probably transferred to Burma and India at a later date through the beheading of the eastern rivers by the younger western rivers which were being produced on the rising slopes of the Himalayas.

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[1] Hora, *Cur, Sci.*, V, p. 354 (1937).
[2] Hora, *Phil. Trans. Roy. Soc. London*, CCXVIII, p. 234 (1930).
[3] Gregory, *Scottish Geog. Mag.*, XLI, pp. 121-141 (1925).

THE INDIAN EPHEMEROPTERA (MAYFLIES) OF THE SUB-ORDER EPHEMEROIDEA.

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(Plates IV & V.)

Introduction.

The study of this interesting group of insects was suggested to me by Dr. Baini Prashad, Director, Zoological Survey of India, with a view to continue the work of my friend and colleague Dr. B. Chopra, whose paper on the Palingeniidae and Polymitarcidae of the sub-order Ephemeroidea was published in 1927.[1] The Mayfly material of the Indian Museum has in the meantime been increased by collections made by the Officers of the Zoological Survey of India and I am therefore obliged to include in this paper references to Palingeniid and Polymitarcid species already dealt with by Chopra, together with the description of a new species of the genus *Anagenesia*. This paper deals with all the Indian representatives of the sub-order Ephemeroidea so far as was possible with the material available. I have, however, not so far seen any material of the family Potamanthidae.

I have, as was done by Chopra, preferred to follow Comstock and Needham's notation of wing venation throughout my work. I have also adopted Ridgway's nomenclature in describing colouration. As is usual in this group, slide mounts of certain appendages of the specimens that I have seen have been made. These are deposited in the collections of the Zoological Survey of India.

I am much obliged to Dr. Baini Prashad, Director, Zoological Survey of India, for his kind guidance and generous help in preparing this paper for the press. I wish to express my grateful thanks to Dr. B. Chopra for his notes and figures on the two new species of *Ephemera*, *viz.*, *E. diffusa* and *E. annandalei*, as also on some other Ephemerid species dealt with in this paper. I have, however, re-examined the specimens that are in the collections of the Zoological Survey of India on which Chopra based his descriptions of the two new species and have made a few alterations and additions to his descriptions and figures. Some of the specimens are, however, in a rather damaged condition. My best thanks are also due to Dr. F. H. Gravely for his kindness in loaning me the Madras Museum material for study and to my assistant, Mr. G. Mathai, for general help rendered in the course of my work. Babu Subodh Mondul, one of the talented artists of the Zoological Survey of India, executed under my supervision some of the illustrations of this paper.

[1] Chopra, B.—*Rec. Ind. Mus.* XXIX, pp. 91-138 (1927).

SYSTEMATIC ACCOUNT.

Suborder EPHEMEROIDEA.

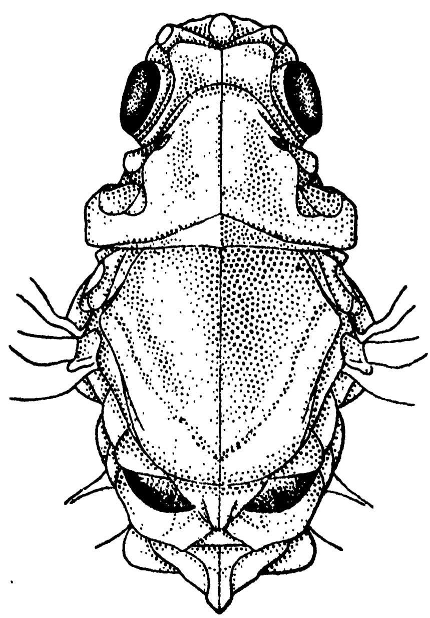
Family PALINGENIIDAE.

Anagenesia lontona, sp. nov.

(Plate IV, figs. 1-3.)

This species is represented in the Indian Museum collection by a single pinned female specimen from Lonton, Upper Burma, collected by Dr. B. Chopra ; the specimen is in a fairly good state of preservation.

Imago ♀ *(dried).*—The general colouration of the body varies from walnut brown to vandyke brown. The head is pitch black ; the eyes are also black, encircled basally with dark brown ; the ocelli are light brown encircled with black ; the lateral ocelli are connected by fine shallow grooves meeting in the middle. The pronotum is well developed, and of a vandyke brown colour except at the sides and at the posterior margins which are somewhat lighter. The anterior corners of pronotum are deeply notched. The mesonotum is slate black, robust, bearing two obliquely running shallow grooves forming a V. The metanotum is more or less of the same colour as the pronotum (Text-fig. 1). The dorsum of abdomen is walnut brown except the last three



TEXT-FIG. 1.—*Anagenesia lontona*, sp. nov.
Head and thorax of female, dorsal view : × 8.

segments, which are vandyke brown and more convex than the anterior segments.. Segments 3 to 7 bear blackish gray semicircular markings ; the free ends of the arches are directed forwards close to the

posterior margins of the preceding segments. The posterior margin of the last abdominal segment is deeply notched in the middle and the rudimentary median caudal seta is visible from above. The venter of thorax is more or less concolourous with the dorsum but that of the abdomen is considerably lighter and the posterior margins of segments, except the last, with pale thick lines.

The wings are dirty-whitish and translucent. The fore-wings are large ; the wing venation is typical of the genus ; M_1, however, appears to fork slightly beyond *Rs* ; there is a single longitudinal vein in the first anal fork ; costa, sub-costa, radius and the great cross vein are prominent and dark brown ; the rest are cream yellow. The neuration of hind-wings is typical of the genus ; the costal projection near the humeral angle is prominent and is of a dark brown colour ; *C*, *Sc*, *R*, *M*, *Cu* and the anal veins are well developed ; the forking of *Rs* is not well marked.

The legs are considerably reduced, particularly the first pair. The coxae of the first and second pairs of legs are concolourous with the sternum ; the femora, tibiae and tarsi are very much lighter. It is difficult to make out the joints of the fore-tarsus owing to its being greatly shrivelled in the only specimen available. The claws of fore-legs are uniunguiculate. The second and third pairs of legs are more strongly developed, but the tarsi are considerably reduced. The hind-tarsus bears one claw.

The lateral caudal setae are ribbon-like, about half as long as the length of the body and uniformly pubescent ; the tips are pointed and brownish ; the median seta, as stated before, is rudimentary and is situated in the middle of the notch of the last abdominal segment.

♂ not known.

Length of body 29 mm. ; fore-wing 26 mm. ; lateral seta 13 mm.

Type specimen.—No. $\frac{963}{H\,8}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—Lonton, a small village on the western shore of the Indawgyi Lake, Myitkyina district, Upper Burma, B. Chopra, 18th to 31st October 1926.

The present species is about the darkest in colour of all the Indian species of the genus *Anagenesia* Etn. that I have seen. It is by far the largest species of the genus, being slightly larger than even the males of *A. robusta* (Etn.). It differs from *A. lata* (Walk.) in its very much larger size and dirty-whitish wings. It is easily distinguished from the Bornean species, *A. picta* (Grav.), by the larger size of its body and wings, darker colouration of notum and abdomen and by the characteristic blackish gray semicircular markings on the 3rd to 7th abdominal tergites.

Anagenesia minor (Eaton).

1927. *Anagenesia minor*, Chopra, *Rec. Ind. Mus.* XXIX, p. 113.

I refer to this species a very large number of male specimens, both pinned and in alcohol, from Belgaum district in the Bombay Presidency. *A. minor*, as remarked by Chopra, certainly appears to be a widely distributed species having been previously recorded from Upper Burma, Bengal and Bihar.

Some of the specimens from Belgaum are much smaller than those recorded by Chopra from other localities, the smallest measuring about 14 mm. They, however, very closely resemble the specimens from Saraghat, Bengal. The characteristic feature of the species, *viz.*, the clouding of the dorsum of the posterior segments of the abdomen is quite clear but the general colouration of the specimens is somewhat lighter. The gray clouding of segments 7-9 is continued to other segments but less and less so anteriorly and very much so in the first segment. Specimens, in which the segments of abdomens are telescoped, have the gray clouding as a continuous mid-dorsal gray band. The terminal joints of the genital forceps are distinctly longer than the preceding ones. In all other characters the specimens agree with previous descriptions.

Locality.—Dhupdal and Gokak, Belgaum district, Bombay Presidency, Baini Prashad and H. S. Rao, November 1928 (at light).

Family POLYMITARCIDAE.

Polymitarcys indicus (Pictet).

1927. *Polymitarcys indicus*, Chopra, *Rec. Ind. Mus.* XXIX, p. 124.

I refer to this rather common species a large number of examples from Gokak, Belgaum district, Bombay Presidency, Sarai, Rewa State. and Kamaing, Upper Burma. The large number of specimens from the Bombay Presidency are all females. Specimens of both sexes from Rewa State include a number of male sub-imagos and the specimens from Upper Burma comprise both males and females.

The specimens agree in all respects with previous descriptions. The number of subsidiary veins in the first anal fork of the fore-wing, ranging from 4 to 6, however, is variable. This character, therefore, does not appear to be of any great importance. The genital forceps in specimens from Sarai, Rewa State, are arranged as described by Chopra, the left forcep being more dorsally placed than the left penis lobe. But in one of the male sub-imagos from the same locality it is the right forcep which is more dorsally placed than the left.

There are altogether six male sub-imagos. In all essentials they show great resemblance to the imagos but the colouration of the mesonotum is very much darker than that of the imago. The first pair of legs are very short. Femur with blackish brown streaks on the outside; tibia very robust and a little longer than the femur and has on its inner and outer surfaces a series of closely placed transverse blackish brown lines giving it a characteristic appearance. Tarsus three-fourths as long as tibia, also robust, the five joints decrease in size proximo-distally ending in unequal biunguiculate claws. The second and third pairs of legs are as in the imago but the tarsi are not so much reduced and the segments are quite clear. The second tarsus has three distinct joints and the third four joints ending with biunguiculate claws. Venation as in the adult; six subsidiary veins in the fork of the first anal vein. Genital apparatus as in the imagos but in one example the right forcep appears to be more dorsally placed than the left. One of the specimens has the cast of the skin attached to the posterior end of the body and the first pair of legs in this specimen are as in the adults.

Locality.—Gokak, Belgaum district, Bombay Presidency (at light), B. Prashad and H. S. Rao, November 1928, Sarai (land) 2,700 ft., Rewa State, H. S. Pruthi, February 1927, Kamaing, Myitkyina district, Upper Burma, B. Chopra, November-December 1926, and Mysore, S. India, Gangadaran, November 1925.

Family EPHEMERIDAE.

Ephemera Linn. and *Hexagenia* Walsh. are the only two of the five known genera of the family so far recorded from India. The former comprises ten species including two species described in this paper as new and also *E. fulvata* described by Navas (1935). The genus *Hexagenia* is, so far as I know, represented by a single species *H. indica* described by Chopra (1924).

Genus **Ephemera** Linn.

Ephemera diffusa Chopra, sp. nov.

(Plate IV, figs. 4-9.)

♂ *Imago* (*in spirit*).—The general colouration of the body is warm sepia to vandyke brown or in some cases burnt umber, with the venter somewhat paler and the dorsum considerably tinged with black.

The head is almost entirely black or rather blackish brown with only a small area in the middle near its posterior end somewhat paler. Another pale circular depression encircles a dark spot above the middle. Eyes are oval in outline with their inner orbits curved, and are separated from one another dorsally by a fairly extensive interspace. The eyes are black and the ocelli slightly lighter. The anterior ocellus is considerably smaller than the paired posterior ones. The antennae are brownish.

The pronotum is long but at its posterior end the breadth exceeds the length. In about its anterior third the pronotum is pale brownish, but the rest of it excluding the margins only is covered by a large quadrilateral patch of vandyke brown. The sides of this quadrilateral patch are almost blackish. The mesonotum is large and is uniformly coloured, vandyke brown to warm sepia ; near its posterior extremity it is somewhat blackish. The metanotum is short and is of the same colour as the pronotum.

The dorsum of the abdomen is vandyke brown, with the margins considerably darker than the remaining surface. The apical borders of all the segments are also appreciably darker than the general surface. The characteristic abdominal markings, which are very prominent, are in the form of slightly curved to straight lines of dark vandyke brown on the segments 2-9, on either side of the median line. In the anterior segments the markings are more or less ovalish while in the last three or four segments they are in the form of slightly bent bands. These bands in the posterior segments extend almost completely from the apical to the basal margins but in the anterior somites they are nearer to the basal than the apical margins. The marginal dark bands run from end to end of the abdomen close to the pleura on each side. There is another sub-median band or streak on each side running close and

parallel to the dorsal line. In the anterior segments this is very faint, but becomes more discernible in the posterior segments, where it becomes considerably broader than anteriorly. The sub-median streaks, except in the ninth segment, are lighter in colour than the large lateral patches. It will thus be seen that the colour markings of the abdomen in *Ephemera diffusa* are more or less exactly like those of *Ephemera supposita* as described by Eaton in the *Journal of the Asiatic Society of Bengal.*

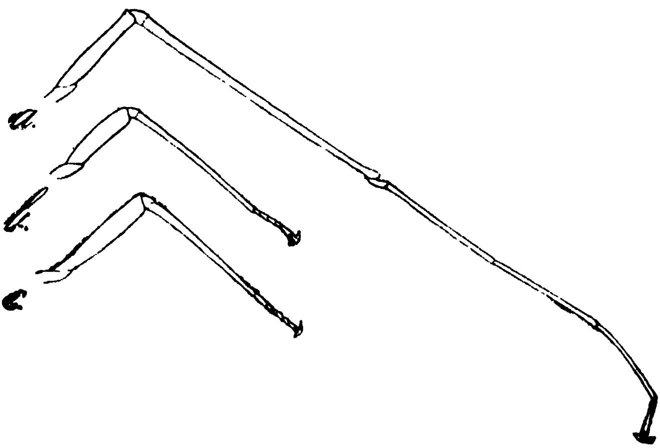
The venter is much lighter than the dorsal surface and there are fairly large and prominent whitish spots on the 9th and the 10th sternites. The prosternum behind the head and the head around the base of the antennae are also whitish.

The fore-wings are perfectly transparent in transmitted light, slightly iridiscent, and are of a shade between antique brown and raw umber (nearer the latter than the former); the terminal and the inner margins are slightly darker than the rest of the membrane. The submarginal area is considerably darker. The longitudinal and transverse veins are opaque and of a raw umber colour. The sub-costa and first radial veins are considerably darker than the other longitudinal veins. The usual spotting of the wing is not at all clear perhaps owing to the specimen being in spirit. The spot in the fork of the media may have been present, but there is no trace of any marking on the *Cu*. R_5 a little beyond the forking of M has a small circular completely transparent spot which originally may have had pigment around it. There is a similar transparent area on R_2 and Sc but they are more proximally situated. The venation is typical of the genus. The costa is well developed; the sub-costa and the first radial are strongly developed. The radial-sector forks well in advance of media, the latter dividing beyond the middle. The cubitus branches quite close to the wing-root, the hinder branch being conspicuously curved near its origin. The first anal is obscurely connected with the cubitus at its base and forms a curve almost similar to that of the posterior branch of *Cu*. A_1 does not give many branches from its inner margin; A_2 is connected at its base to A_1; A_3 near the inner margin runs parallel to A_2.

The hind-wing is concolourous with the fore-wing. The membrane is transparent and is more or less raw umber in colour; near the margins the membrane is much darker. There are no colour spots and the veins are not edged with colour. The costal projection is fairly conspicuous; Rs arises from R_1 and is forked quite near the wing base. M also divides near the fork of Rs and as usual M_3 joins Cu. The veins of the inner margin are not very prominent.

The legs, except for some parts of the fore-legs, are somewhat lighter in colour than the body (Text-fig. 2). The tibia of the fore-leg is vandyke brown, but the outer surface of the femur has a number of pale longitudinal streaks. The tarsus is considerably paler than the tibia. The second and third legs are somewhat light umber-brown with darker streaks on the femora. In their structure the legs are more or less typical of the genus. The fore-legs are very long and are about as long as or even longer than the body. The tibia is a little less than 3 times as long as the femur, while the tarsus is 4 times as long. The tarsus

is formed of 4 long, distinct segments and a rudimentary basal joint. The 4 large tarsal segments decrease in size progressively from the first



Text-fig. 2.—*Ephemera diffusa* Chopra, sp. nov.
a. 1st leg of male : × 7 ; *b.* 2nd leg of male : × 7 ; *c.* 3rd leg of male : × 7.

to the last ; the first is only slightly longer than the second and is almost equal to the third and the fourth joint together ; the 3rd is about twice as long as the 4th. Both the claws are similar. The second leg, the shortest of the three, is only a little shorter than the third. The femora of the 2nd and 3rd legs are of about the same length as that of the 1st ; the tibiae and tarsi of the 2nd and 3rd legs are less than even a third as long as those of the 1st. The tarsi of the last two pairs of legs are small, being about a third of the length of the tibiae. The tarsus is formed of 5 joints, the basal rudimentary segment is also more or less fully differentiated. The tarsal joints are sub-equal, except the ultimate one which is the longest.

The genital apparatus is lodged in a deep concavity of the very short 10th tergite. The forceps are concolourous with the venter. Each forcep is formed of 4 distinct segments. The two terminal segments of each are small, about as long as the basal and less than half as long as the 2nd. The basal segment is stout and the 10th tergite near its origin has a short spine. The second segment has a large prominence on its inner side near the base, is grooved ventrally and has hairs all along the groove. The penultimate and the terminal segments are hairy. The penis lobes are of the same colour as the venter and are proportionately very small in size ; they are lodged in a deep concavity of the 10th sternite, but a thin membrane-like structure covers their basal portions. The lobes are short, stumpy, finger-shaped, distally rounded, each having a sharp spine about as long as the lobe itself lying by its side along the inner margin. The presence of any such spine in connection with the genital apparatus has not been observed in any other mayfly and it is difficult to make any suggestion regarding its function, etc. The spine on the tergite near the base of the forcep is also unusual.

The setae are thin and long and are more or less circular in cross section. The setae in most of the specimens are broken, but the median seta appears to have been almost quite as long as the lateral ones. The setae are vandyke brown in colour, but in some specimens are antique brown especially towards their posterior ends. They are clearly segmented and are uniformly setose.

♂ *Sub-imago (in spirit)*.—This differs from the imago in being much lighter in colour. The wings are pale, dirty whitish with yellowish costal shoulder and brownish (darker near the wing base than distally) sub-costal and first radial veins. The principal veins are light brownish near the root but are milky whitish distally. Except in the sub-costal region most of the transverse veins are whitish and opaque. The dorsum of the abdomen is much lighter in colour than that of the adult but the colour markings in the two are identical. The prothorax is proportionately much shorter than that of the adult.

The legs in the proportion of their component parts resemble those of the female sub-imago more closely than those of the ♂ imago. In the fore-leg the femur is proportionately large and the tarsus is correspondingly reduced. The genital forceps are like those of the adult but the penis lobes are small. The caudal setae are long and have very prominent dark brown joints.

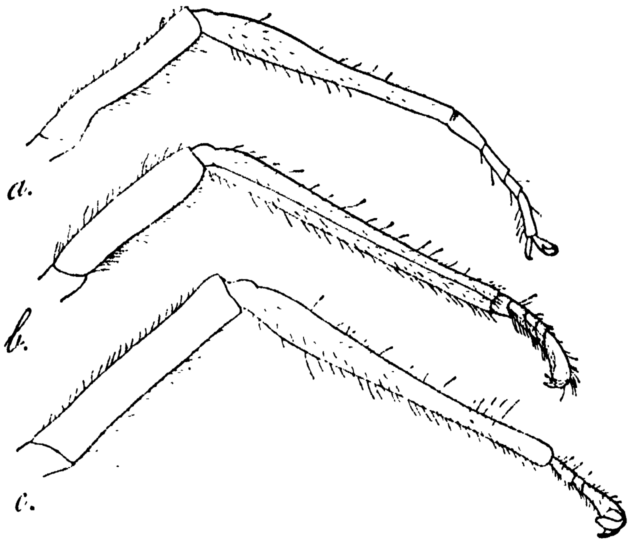
♀ *Sub-imago (in spirit)*.—The body is much paler in colour than that of the male imago. It is raw sienna above in places becoming antique brown to raw umber and is maize yellowish below. The head is dark brown and the eyes are blackish. The pronotum is short and is distinctly transverse. The notum has small irregular short setae of antique brown. The dorsum of the abdomen appears to have the same scheme of colour markings as that of the male but the marginal row of markings is hardly visible. The sub-median and the lateral rows are very well defined. The venter and the sides, as already mentioned, are light maize yellow.

The wings are dull whitish, with a pale tint in certain aspects and the veins are whitish. The sub-marginal area in the fore-wing is grayish. This wing, as compared with that of the male, is slightly longer and narrower, but the venation in the two appears to be more or less identical. The meta-thoracic wing is concolourous with the fore-wing and the venation is exactly like that of the hind-wing of the male.

The legs are more or less of the same colour as the venter (Text-fig. 3). The fore-leg has, however, a dull brownish streak on the femur and another on the tibia. The fore-leg is much shorter than the body; the femur is slightly over $\frac{3}{4}$ as long as the tibia and is somewhat longer than the tarsus. The latter consists of 4 distinct and one indistinct (basal) segments. Of the 4 segments the ultimate is the longest, while the 3rd is the shortest; the first is longer than the 2nd and is considerably shorter than the last. The claw is well developed and the two halves are dissimilar. In the 2nd leg the tibia is twice as long as femur and the tarsus is reduced. Of the 4 distinct segments, the last is by far the longest and the other three are sub-equal. In the last leg the tarsus is further reduced and the segments are not clearly seen.

The setae are dirty whitish with brown joints, which become considerably faded distally.

Along with the specimens described above a large number of cast sub-imaginal skins were also collected. Both sexes are represented



TEXT-FIG. 3.—*Ephemera diffusa* Chopra, sp. nov.
a. 1st leg of female sub-imago : × 20 ; *b*. 2nd leg of female sub-imago : × 20 : *c*. 3rd leg of female sub-imago : × 20.

but the females far outnumber the males. The characters briefly mentioned above for male and female sub-imagos are clearly brought out by the specimens. They are transparent, whitish with only certain thoracic parts raw sienna.

Length of body, ♂ imago 10 mm., sub-imago 10·5 mm., skins up to 13 mm., ♀ sub-imago 10·5 mm., skins 11-15 mm., wings ♂ imago 10·5 mm., sub-imago 11 mm., ♀ sub-imago 11 mm. ; setae ♂ imago up to 22 mm., sub-imago 16 mm., skins 18 mm., ♀ sub-imago 15 mm., skins up to 13·5 mm.

Nymph not known.

Type specimens.—♂ imago No. $\frac{964}{H8}$, ♂ sub-imago No. $\frac{965}{H8}$, and ♀ sub-imago No. $\frac{966}{H8}$. Paratypes.—♂ imagos No. $\frac{969}{H8}$. A fairly large number of cast sub-imaginal skins No. $\frac{970}{H8}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—All the specimens described above were collected by Dr. H. S. Rao in October 1924, sitting on a wall on the bank of the Bhavani river at Bhavani in the Coimbatore district. It is stated by Dr. Rao that the wall was covered with thousands of cast skins of which a few were collected. Also taken at Mettupalliyam, Gravely, 10-vi-1928.

E. diffusa is easily distinguished from *E. immaculata* Eaton[1] by its smaller size and warmer colour and by the penis lobes being shorter. It differs from *E. expectans* (Walk.)[2] by its more prominent abdominal markings.

[1] Eaton, A. E.—*Trans, Ent. Soc. London*, p. 74 (1871).
[2] Walker, F.—*ibid*, 198 (1860).

Ephemera annandalei Chopra, sp. nov.

(Plate V, figs. 1-4.)

A single male specimen in certain respects resembling very closely *E. expectans* (Walk.) is in the collection of the Indian Museum.

♂ *probably Sub-imago (in spirit)*.—The general colour, as in *E. expectans*, is white but there is considerably more of brown on the dorsal surface. The head is very pale orange yellow, with a few short irregular streaks scattered on it. The eyes are slate gray and the ocelli are white with grayish broad rings at their bases. The pronotum is also pale orange yellow with broad areas along each side suffused with vandyke brown and a distinct fairly broad streak of the same colour on each side. The median area between the streaks is whitish. The mesonotum is mostly whitish but in parts maize yellowish and has two broad curved streaks one on each side. These streaks are continued into broad patches of raw sienna to antique brown. The metanotum is suffused with small brownish spots.

The colour markings of the abdomen are principally very much like those of *E. expectans*, but the streaks are not chocolate but clove brown to blackish brown. The whitish ground surface of the dorsum is much less visible in between the streaks in the present species than in *E. expectans*. In segments 3-9 there are three clearly visible streaks on each side. The sub-median streak is slanting so that it meets its companion of the opposite side at the anterior end of the tergite. The laterals and marginals are more or less straight and run parallel to one another, the latter being quite close to the margin. In the 9th segment these two streaks more or less meet one another so that there appears to be one broad band on each side. In the first two segments the streaks are not differentiated, so that there is a general suffusion of colour. On the 10th tergite there is a blackish square spot on each side in continuation with the side streak and a crescent-shaped arch at the bases of the setae.

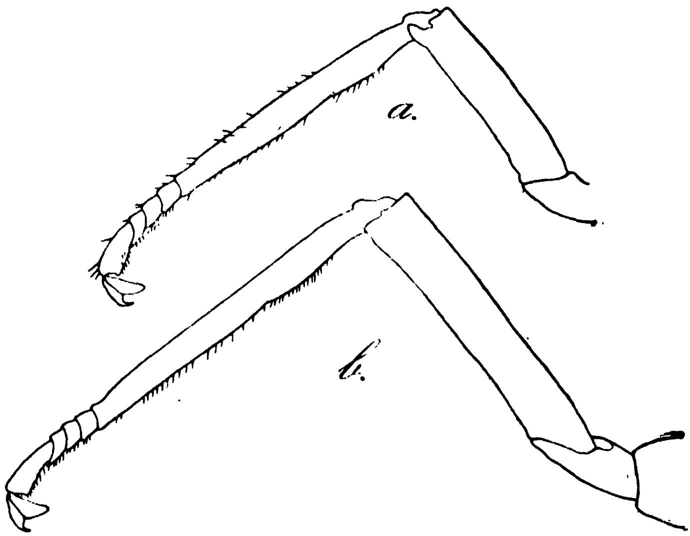
The venter is like that of *E. expectans* there being 2 rows of streaks on the abdomen; those on the 9th being much broader than the others. Between the bases of first legs there is a faint triangular spot. The sides are concolourous with the venter, but in the thorax there is a short streak near the mesothoracic wing-root. On the sides of the abdomen there is a short streak on each segment and some of the spiracles are also encircled with brown.

The wings are dirty-whitish, with the sub-costal area of the fore-wing very pale yellow orange. The membrane is dull but transparent and the longitudinal veins except the *Sc* and *R* are opaque and white. The sub-costa and the first radius are pale yellowish orange. The transverse veins are vandyke brown to warm sepia. There are no transverse veins near the inner margin. At the bifurcation of *M* there is a large and very prominent spot and the other 3 spots are also present in the usual position though considerably smaller than that of *M*. The venation is like that of *E. expectans*, but there are fewer subsidiaries given from A_1 to the margin.

The hind-wing is concolourous with the fore-wing and the longitudinal and the transverse veins are also of the same colour. The venation

is typical of the genus and the posterior branch of *M* distinctly arises from Cu_1.

The legs are concolourous with the venter and are for the most part devoid of prominent colour markings (Text-fig. 4). In the fore-leg[1]



TEXT-FIG. 4.—*Ephemera annandalei* Chopra, sp. nov.
a. 2nd leg of male sub-imago : × 22 ; *b.* 3rd leg of male sub-imago : × 22.

the tibia has a longitudinal streak of vandyke brown and one or two of the same colour, but fainter, are present on the femur. The coxa of the 3rd leg has a dark brownish spot on its anterior surface. The fore-tarsi of both the sides are broken but the fore-tibia (as is the case in all sub-imagos) is comparatively shorter, being only slightly longer than the femur. In the 2nd and 3rd legs the tibia is much longer than the femur and the 3 basal joints of the tarsus are sub-equal while the terminal is the longest ; a 5th rudimentary joint is hardly differentiated.

The genital forcep is of the same colour as the venter and has a very fine brownish streak along the outer margin. Of the 4 segments, of which it is formed, the basal is short and stout and has a prominent rounded projection on the inner side of its posterior extremity. The second joint is the longest, is curved and slightly grooved ventrally, there being hairs all along the sides of this groove. The last two segments are small, but the penultimate is about twice as long as the last. There is a small and faint brownish streak at the junction of the 2nd and 3rd joints. The concavity formed by the 9th sternite to receive the genital apparatus is fairly deep. The penis lobes are short and triangular with the apices very slightly rounded. The spine-like structure near the bases of the forceps is prominent and is a little larger than the penis lobes. It is finger-like and rounded at the base.

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[1] The fore-legs are missing from the specimen and I have not been able to trace them from slides either.

The setae are dirty-whitish on the underside with white joinings near the base. On the upper surface and the outer sides the joints are brown and the general surface is also suffused with brown. Somewhat away from the base there is a brownish patch on each segment besides the ring of the same colour. Near the posterior end the setae are rounded and the joints are brown all round. The median seta is almost as long as the lateral.

Length of body 15 mm., fore-wing 13·5 mm., setae 14·5 mm.

♀ *Imago* (*in spirit*).—The colouration of the head, thorax and abdomen is like that of the male, though it is slightly less white, being palish. The abdominal markings are also similar, though somewhat brighter. The wings are transparent and iridescent. The dirty-whitish colour of the wing of ♂ is no doubt due to the specimen being a sub-imago. The yellowish orange tint of the longitudinal veins in the costal region is more well marked than in the ♂.

The colouration and structure of the legs are more or less as in ♂. The wing venation is also apparently like that of the ♂.

Setae are as in male, but broken.

Length of the body 15 mm., fore-wing 15 mm., setae broken but appear to be about 14 mm.

Nymphs not known.

Type specimens.—♂ sub-imago No. $\frac{967}{H8}$ and ♀ imago No. $\frac{968}{H8}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—The single male specimen was collected at Shillong (Assam) at an altitude of 4,500 ft. by Dr. N. Annandale in April 1918. The female specimen was collected by Mr. T. B. Fletcher at Shillong in November 1924.

The species superficially resembles *E. expectans*, but may easily be distinguished from it in having a considerably warmer colour and in the dorsum being more profusely and darkly coloured. The wing membrane is not quite as dull and whitish as in *E. expectans*. The markings on the dorsum of the abdomen are also different in the two species. There are fewer subsidiary veins going to the inner margin from A_1 than in *E. expectans* and the spine-like structure on the side of the penis lobe more pointed and finger-like.

Since Dr. B. Chopra wrote the foregoing description of the present species a large number of female imagos both pinned and in alcohol have been collected by him at light from Lonton, Upper Burma. The tibia of the fore-leg in these specimens has dark chocolate brown rings at the proximal and distal ends. The transverse veins of wings are also dark chocolate brown.

There are two more female specimens in spirit from Namkhai river, Kutkai, North Shan States, Burma (4,500 ft.) collected by Dr. H. S. Rao in November, 1926. The specimens are somewhat damaged and the fore-legs in both the specimens are missing. Setae are broken but the wings are in a fairly good condition. I have placed these specimens under this species with some doubt, as the characteristic abdominal markings are not so very prominent and the general appearance is like that of *E. expectans*. They, however, differ from *E. expectans* by their longer bodies and shorter wing expanse.

There are 5 more pinned females from Nyaungbin, Upper Burma, collected by Dr. B. Chopra in November 1926, which closely resemble *E. annandalei* in their general appearance and wing venation but differ like the specimens from Lonton in having the ends of the tibiae of the fore-legs coloured dark chocolate brown. The broader ungues of the second and third claws are also dark brown as in the specimens from Lonton.

I also refer to this species a female specimen (in spirit) from Sagar, Shimoga district, Mysore, collected at light by Dr. H. S. Rao (1. xii. 1928), a specimen from Danster Wah, Bubak, Sind, collected by Dr. B. Prashad and Dr. B. Chopra (21-23. xi. 1927), and three more females (in spirit) from near Harai, altitude 2,700 ft., Rewa State, collected by Dr. H. S. Pruthi (February 1927). From more or less the same locality (Opposite the Camp at Harai, 2,625 ft., Rewa State, March 1927) Dr. H. S. Pruthi also collected a single male. The male specimen is in a fairly good condition and as Chopra described only the ♂ sub-imago, I give below the description of what I consider to be an adult.

♂ *Imago (in spirit).*—There is only a superficial difference between the adult and the sub-imago in that the general colouration of the former is much darker than that of the latter.

The front portion of the head is damaged but the general structure appears to be the same as in the sub-imago. The thorax is more darkly coloured, approaching umber brown, especially at the sides of the mesonotum.

The abdominal markings are better defined than in the sub-imago but the abdomen appears to be shorter than that of the sub-imago.

The fore-legs are missing in this specimen. The coxae and femora of the second and third pairs of legs are concolourous with the sides of the thorax. The coxae of third pair of legs on their outer surface have a dark brown spot. The tarsi of both the pairs of legs end in biunguiculate claws. Structurally the second and third pairs of legs are very similar to those of the sub-imago.

The wings are clear and transparent, with the sub-costal area light brown. The longitudinal veins, especially the first three, are conspicuously brown. The transverse veins are also brown. The wing venation is similar to that of the sub-imago.

The genital apparatus is lodged in the concavity of the last abdominal segment, and the general structure is similar to that in the sub-imago. Only one lateral seta of a dirty-whitish colour with brownish joints is present in the specimen.

Length of body 13 mm., fore-wing 12 mm., lateral seta 23 mm.

Distribution.—*E. annandalei* has a fairly wide range of distribution, extending from Upper Burma in the east to Sind in the west and as far down south as Mysore in the Peninsula.

Ephemera immaculata Eaton.

(Plate V, figs. 8-11.)

1871. *Ephemera immaculata*, Eaton, *Trans. Ent. Soc. London*, p. 74, pl. iv, fig. 10.
1883. *Ephemera immaculata*, Eaton, *Trans. Linn. Soc.* London, (2), III, p. 72.
1920. *Ephemera immaculata*, Ulmer, *Entomol. Zeitung. Stettin.* LXXXI, p. 109.
1927. *Ephemera immaculata*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 95.

Eaton's description of *E. immaculata* is too inadequate to enable one to recognise it satisfactorily, but as a number of specimens in the Indian Museum agree fairly closely with Eaton's description I have considered it best to identify them with Eaton's species. The specimens are from Bangalore in South India ; Eaton's example came from "Cuna ".[1] I have also examined a single male from the same locality captured by Dr. Gravely in May 1921 and preserved in the collection of the Madras Museum.

The general colouration of the specimens is somewhat lighter than that described by Eaton, but this may be due to preservation in spirit for a number of years.

The head and the thorax are pale brownish, the latter being darker than the former. The eyes are grayish and the ocelli are white encircled with chestnut brown. Behind the ocelli there are two short, parallel, longitudinal streaks of a chestnut colour not extending to the anterior margin of the pronotum. The thorax is pale brownish with a few darker streaks. The abdomen is dark, and the tips of the segments and the spiracular lines are considerably darker. The penultimate segment of the abdomen is considerably darker than the rest of the abdomen. The venter and the sides are lighter than the dorsal surface. The lateral margins of the penultimate abdominal sternites are streaked with brown.

The legs are more or less concolourous with the venter. The femur of the fore-leg is considerably lighter than the rest of that limb. The tarsi of all the legs are very light, almost pale whitish. The setae are light brownish, somewhat warmer in the proximal portions.

The wings are spotless; the usual spots on *Sc*, *Rs* and near the fork of *M*, so characteristic of the other species are absent. The membrane of the fore-wing is clear and more or less devoid of colour. The coloured veins, however, make it appear somewhat brownish. The veins are raw sienna to antique brown. The cross veins in the submarginal area especially towards the base are considerably darker than in the rest of the wing. The venation is more or less typical of the genus. *Rs* forks well in advance of *M*, the latter dividing somewhat about the middle. The disposition of *Cu*, *A* and their branches is very similar to that of *E. diffusa*.

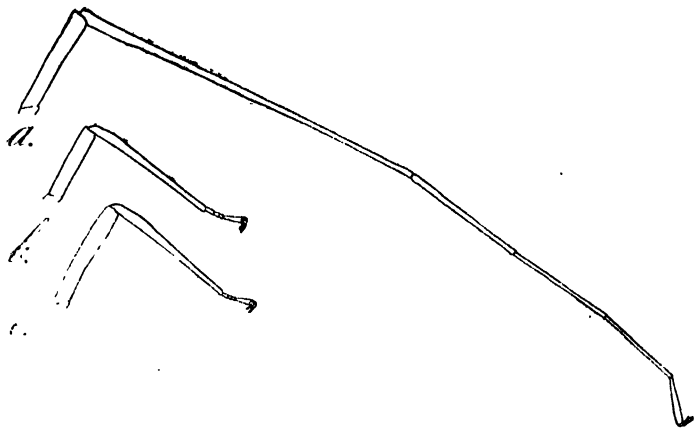
The terminal margin of the hind-wing is coloured raw sienna like the sub-marginal area of the fore-wing. The marginal and sub-marginal areas near the wing root are also lightly tinted. The venation is more or less typical of the genus. The costal projection is very prominent; *Rs* forks near the wing base and the second branch of *M* is joined on to *Cu*. The venation in the hinder portion of the wing, somewhat contrary to rule, is rather well developed, the anals being quite prominent.

The legs are very well developed, those of the first pair being very long (Text-fig. 5). The first legs are broken in all the specimens. The tibiae and the tarsi of the second and the third pairs of legs are reduced.

[1] I have not been able to trace "Cuna", it may probably be a *lapsus calami* for Guna in Gwalior.

The mid-tarsus consists of 5 segments; the first joint is rudimentary and the terminal is by far the longest. The third leg is similar to the second.

The genital apparatus is very like that of *E. diffusa*. The forceps are concolourous with the venter and have the usual structure. The



TEXT-FIG. 5.—*Ephemera immaculata* Eaton.
a. 1st leg of male : × 10 ; *b.* 2nd leg of male : × 10 ; *c.* 3rd leg of male : × 10.

terminal segment appears slightly shorter than the sub-terminal. A shallow protuberance is visible along the outer side of the base of the second segment. The spine of the 10th sternite near the base of the forceps is fairly well developed. The cup-like concavity of the last sternite formed for the genital apparatus is rather shallow. The penis lobes are finger-shaped structures arising from a quadratic basal area and are proportionately longer than those in *E. diffusa*; the spines on their inner sides are considerably longer than the lobes themselves.

The three setae have the usual structure and are sub-equal in length. They are light brown near their bases, but become lighter distally.

There are no females or nymphs in the collection before me.

Length of body ♂ imago up to 12 mm., fore-wing up to 11·5 mm.; setae missing in most of the specimens.

Distribution.—Eaton's type which is stated to be in the Hope Museum, Oxford, came from Cuna, but this is possibly a misprint for Guna in Gwalior. The specimens that I assign to *E. immaculata* are from Bangalore (alt. *ca.* 3,000 ft.) and most of them were collected by the late Dr. Annandale in October 1910. All these specimens are males. Also taken at Bangalore (alt. *ca.* 3,000 ft.) by Dr. Gravely in May 1921.

Remarks.—*E. immaculata* as described above seems to resemble the South Indian *E. diffusa* in several respects. It is, however, slightly larger in size and is of a much lighter colour. The wing membrane is very differently coloured, and the male genitalia are very different.

Ephemera expectans (Walker.)

1860. *Potamanthus expectans*, Walker, *Trans. Ent. Soc. London*, (n. s.) V, p. 198.
1871. *Ephemera expectans*, Eaton, *Trans. Ent. Soc. London*, p. 74.
1883. *Ephemera expectans*, Eaton, *Trans. Linn. Soc. London*, (2) III, p. 72.
1913. *Ephemera vedana*, Banks, *Proc. Ent. Soc. Wash.* XV, pp. 137-138.
1920. *Ephemera expectans*, Ulmer. *Entomol. Zeitung. Stettin.* LXXXI, p. 109.
1927. *Ephemera expectans*. Lestage. *Ann. Soc. Ent. France* XCVI, p. 95.

♂ *Imago* (*in spirit*).—There is a single male specimen from Naukuchia Tal (alt. 4,200 ft.), Kumaon Hills, collected by Dr. S. W. Kemp (5. v. 1911). It agrees with previous descriptions of the species, except for the colouration. This difference, however, may be due to the specimen having been in spirit since 1911. The measurements of this specimen are :—Length of body 13·5 mm., wing 12 mm.

I also refer to this species a large number of rather damaged adult females collected by Dr. B. Chopra (12-15. xi. 1926) from Chaungwa, Upper Burma. These specimens closely agree with Eaton's description in his well known monograph. Their measurements are almost identical with those of the female sub-imagos described by Eaton. I have also seen five male specimens preserved in the Madras Museum and collected by Gangadaran from Mysore in November 1925.

Ephemera supposita Eaton.

(Plate V, figs. 5-7.)

1858. *Potamanthus fasciatus*, Hagen, *Verh. Zool. Bot. Gessells. Wien.* VIII, p. 476.
1871. *Ephemera fasciata*, Eaton, *Trans. Ent. Soc. London*, pp. 74-75, pl. iv, figs. 11, 11*a*.
1883. *Ephemera supposita*, Eaton, *Trans. Linn. Soc. London*, (2), III, pp. 72-73, pl. viii, fig. 12*c*.
1891. *Ephemera supposita*, Eaton, *Journ. As. Soc. Bengal*, LX, pp. 409-410.
1920. *Ephemera supposita*, Ulmer, *Entomol. Zeitung. Stettin.* LXXXI, p. 109.
1921. *Ephemera supposita*, Ulmer, *Arch. f. Naturg.* LXXXVII, p. 261.
1924. *Ephemera supposita*, Lestage, *Ann. Soc. Ent. Belgique*, LXIV, p. 39.
1927. *Ephemera supposita*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 97.

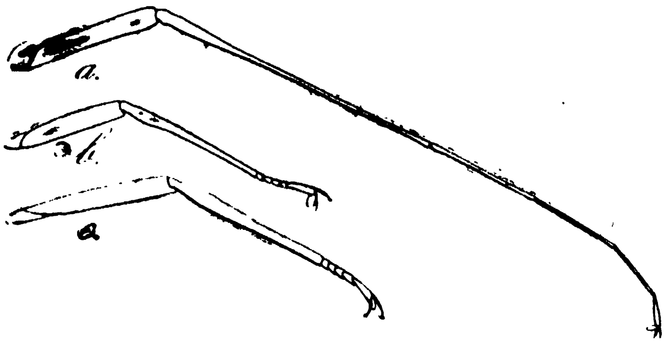
None of the specimens identified by Eaton as *E. supposita* are preserved in the collection of the Indian Museum.

Three pinned males collected in the Malabar district in South India and preserved in the collections of the Madras Government Entomologist at Coimbatore are referred to this species. The 3 specimens, which were examined by Dr. Chopra, the present Government Entomologist at Coimbatore informs me, are not present in his collections. I, however, give below a few notes Dr. Chopra made while examining the specimens together with the figures which were prepared under his supervision.

"In general colouration the specimens agree closely with the published accounts. The general tint of the dorsum is more of vandyke brown than bistre, but this may be due to the fact that Eaton's examples were, as stated by him, faded. The head is considerably darker than the rest of the body, and there are two dark squarish patches near the posterior margin of the pronotum. The mesonotum is lighter in colour (approaching testaceous) than the abdomen and the metanotum

is in places still lighter. The colour pattern of the abdomen seems to agree closely with Eaton's account. The venter is somewhat lighter than the dorsum.

The fore-legs in two specimens are missing, while only one is present in the third (Text-fig. 6). The femur is brownish, while the tibia,



TEXT-FIG. 6.—*Ephemera supposita* Eaton.
a. 1st leg of male : × 9 ; *b.* 2nd leg of male : × 9 ; *c.* 3rd leg of male : × 9.

especially towards its distal end, is considerably darker. The tarsus is also dark brown. Hind-legs are much lighter in colour, yellow-umber, as described by Eaton and have the ungues considerably darker.

The setae are umber brown proximally, and the distal parts are yellow. The joints are reddish brown to blackish.

The colouration of the wings is exactly as described by Eaton and the four colour spots described by him are well seen. The venation is quite typical of the genus.

The hind-wing is coloured like the fore-wing. The sub-costal vein is brown. The other longitudinal and cross veins are as in the fore-wing. The terminal margin, as also a part of the inner margin is clouded with grayish colour, very lightly tinted with brown.

The genital forceps are as described by Eaton; they are dull yellowish in colour (with a slight shade of brown) and the two terminal joints are black.

Length of body, ♂ 17 mm., fore-wing 16·5 mm., setae 39 mm."

I refer to this species 3 specimens (in spirit). They were all collected from Peradeniya, Ceylon, 1,500 ft. by Drs. N. Annandale & F. H. Gravely. Two are males and the third is a female. The female appears to be a sub-imago and is in a damaged condition. One of the males also appears to be a sub-imago. It is 15 mm. long, and in general characters is very similar to previous descriptions.

The female sub-imago is only 13 mm. long. Its general colouration is lighter than that of the ♂ sub-imago.

Locality.—The three pinned specimens that were referred to this species by Dr. B. Chopra were lent to him for examination by the Madras Government Entomologist at Coimbatore. Two of these were collected at Santhanatbod in the Malabar district at an altitude of 2,500 ft. in the month of October 1917. The third specimen came from near a stream at Taliparamba and was captured in October 1908. All the specimens

were dry males and were said to be in quite a good state of preservation. A single male specimen was also collected by Dr. Gravely from Kodaikanal, Palni Hills (alt. *ca.* 6,500—7,500 ft.) in May-June 1926 and is preserved in the Madras Museum. Eaton's specimens were from Rambodde, Ceylon.

Ephemera remensa Eaton.

1891. *Ephemera remensa*, Eaton, *Journ. As. Soc. Bengal*, LX, pp. 410-412.
1920. *Ephemera remensa*, Ulmer, *Ent. Zeitung. Stettin.* LXXXI, p. 109.
1927. *Ephemera remensa*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 96.

Of the five male imagos from Kulu on which Eaton based his description of this species only three pinned specimens are preserved in the collections of the Indian Museum. All the specimens are in a pretty bad condition, the abdomen and the head of one being completely lost and in the other two badly damaged. The wings in the specimen without the abdomen and the head are, however, in a good state of preservation. In the spirit collection there are a few fragments of another specimen, including a portion of the male genital apparatus and a leg.

Typespecimens.—Nos. $\frac{6942\text{-}43}{1}$, $\frac{6946}{1}$ and $\frac{6948}{1}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—Kulu, Western Himalayas.

Ephemera consors Eaton.

1891. *Ephemera consors*, Eaton, *Journ. As. Soc. Bengal*, LX, pp. 412-413.
1920. *Ephemera consors*, Ulmer, *Ent. Zeitung. Stettin.* LXXXI, p. 109.
1927. *Ephemera consors*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 99.

Of the two ♂ imagos and two ♀ sub-imagos from the Indian Museum on which Eaton based his description of the species only one male imago and one female sub-imago (both pinned) are available in the Indian Museum collections. The specimens are in a very poor condition, the sub-imago having lost its abdomen completely. The imago too possesses only a portion of the abdomen. The wings in both the specimens are, however, in good condition and so are some of the legs.

Typespecimens.—Nos. $\frac{5852}{5}$ and $\frac{5855}{2}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—Kulu, Western Himalayas.

Ephemera pulcherrima Eaton.

1892. *Ephemera pulcherrima*, Eaton, *Trans. Ent. Soc. London*, pp. 185-186.
1927. *Ephemera pulcherrima*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 99.

I have not so far seen any specimen belonging to this species. From Eaton's description, which is fairly detailed, the species appears to resemble *E. annandalei* described in this paper as new. Eaton's species is, however, much smaller, measuring 12 mm. in length while *E. annandalei* is 15 mm. long. The single female on which Eaton based his description is probably in the British Museum, and came from Tenasserim Valley.

Genus **Hexagenia** Walsh.

Hexagenia indica Chopra.

1924. *Hexagenia indica*, Chopra, *Rec. Ind. Mus.* XXVI, pp. 416-418.

H. indica is the only species of the genus *Hexagenia* Walsh. so far described from India. There are altogether eleven specimens belonging to this species in the Indian Museum collections. All the specimens are females, the male being unknown, and two of them are pinned. The specimens were collected by the late Dr. Annandale on the surface of the Chilka Lake off Barkuda Id. in August 1919.

Family POTAMANTHIDAE.

Of the seven known genera of the family only four, *viz.*, *Potamanthus* Pict., *Rhoenanthus* Etn., *Rhoenanthodes* Lest. and *Potamanthodes* Ulm. have so far been recorded from India. A useful key is provided by Lestage in his "Contribution a L'Etude des Larves des Ephemeropteres" for recognising the genera and species. As stated in the introduction, I have not so far seen any mayflies belonging to this family.

Genus **Potamanthus** Pictet.

Potamanthus subcostalis Navas.

1932. *Potamanthus subcostalis*, Navas, *Rev. Acad. Cienc. Zaragoza*, XV, pp. 17-18.

This species appears to have been described from females only and the locality is given as Khandala (Bombay).

Genus **Rhoenanthus** Eaton.

Rhoenanthus posticus Bks.

1914. *Rhoenanthus posticus*, Banks, *Proc. Acad. Nat. Sc. Philadelph.* LXVI, p. 613.
1930. *Rhoenanthus posticus*, Lestage, *Mem. Soc. Ent. Belgique*, XXIII, p. 131.

This species described by Banks was recorded from Kandy, Ceylon.

Genus **Rhoenanthodes** Lestage.

Rhoenanthodes amabilis (Eaton).

1892. *Rhoenanthus amabilis*, Eaton, *Trans. Ent. Soc. London*, pp. 188-189.
1925. *Rhoenanthus amabilis*, Ulmer, *Arch. f. Naturg.* XCI, heft V, p. 100.
1930. *Rhoenanthodes amabilis*, Lestage, *Mem. Soc. Ent. Belgique*, XXIII, p. 136.

This species was originally described by Eaton under the genus *Rhoenanthus* from a single ♂ imago (dried) collected from the Tenasserim Valley. Lestage has, however, created a new genus *Rhoenanthodes* to accommodate this species and has redescribed it. The species, as Lestage redescribed it, is also known to occur in China and Tonkin.

Genus **Potamanthodes** Ulmer.

Potamanthodes formosus (Eaton).

1892. *Potamanthus formosus*, Eaton, *Trans. Ent. Soc. London*, pp. 186-188.
1919. *Potamanthodes formosus*, Ulmer, *Arch. f. Naturg.* LXXXV, heft XI, p. 11.
1925. *Potamanthodes formosus*, Ulmer, *Arch. f. Naturg.* XCI, heft V, p. 98.
1930. *Potamanthodes formosus*, Lestage, *Mem. Soc. Ent. Belgique*, XXIII, p. 139.

Eaton based his description of the species on dried male and female imagos. Ulmer in 1920 redescribed the species and referred it to his new genus *Potamanthodes*. Eaton's specimens came from the Tenasserim Valley and the species has since been recorded from Japan, China, Tonkin and Formosa.

The following is a list of Indian Ephemeroptera of the sub-order Ephemeroidea which have been described in journals I have not been able to consult and specimens of which I have not so far seen :

Family Palingeniidae.—*Anagenesia birmanica* Navas, *Mem. Accad. Nuovi Lincei* (2), XVI, p. 954, 1932 (Burma).

Family Polymitarcidae.—*Polymitarcys birmanus* Navas, *Mem. Pont. Accad. Sci.* (2), XVII, p. 87, 1933 (Burma).

Family Ephemeridae.—*Ephemera fulvata* Navas, *Broteria Ci. Nat.*, XXXI, pp. 100-101, 1935. (Lonawla near Khandala, Bombay).

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[The following list is supplementary to the bibliography published by Chopra in 1927.]

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Lestage, J. A., 1927.—Une *Ephemera* nouvelle du Tonkin et tableau des espéces de la faune orientale. *Ann. Soc. Ent. France*, XCVI, pp. 93-100.

Lestage, J. A., 1930.—Contribution á l'Etude des Larves des Ephemeropteres—Le groupe Potamanthidien. *Mem. Soc. Ent. Belgique*, XXIII, pp. 73-146.

Navas, R. P. L., 1932.—Commanicaciones Entomologieas. *Rev. Acad. Cienc. Zaragoza*, XV, p. 17.

Navas, R. P. L., 1932.—" Description of *Anagenesia birmanica* sp. nov. from Burma ". *Mem. Accad. Nuovi Lincei* (2), XVI, p. 945.

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Ulmer, G., 1933.—Revised key to the genera of Ephemeroptera. *Peking Nat. Hist. Bull.* VII, pp. 195-218, pls. i-ii.

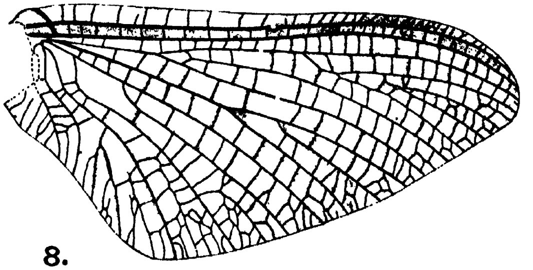
EXPLANATION OF PLATE IV.

Anagenesia lontona, sp. nov.

FIG. 1.—Forewing of female : × 4.
FIG. 2.—Hindwing of female : × 4.
FIG. 3.—Abdomen of female, dorsal view : × 4.

Ephemera diffusa Chopra, sp. nov.

FIG. 4.—Head and prothorax of male, dorsal view : × 16.
FIG. 5.—Abdomen of male, dorsal view : × 10.
FIG. 6.—Genitalia of male, ventral view : × 28.
FIG. 7.—Penis lobes : × 70.
FIG. 8.—Forewing of male : × 8.
FIG. 9.—Hindwing of male : × 8.



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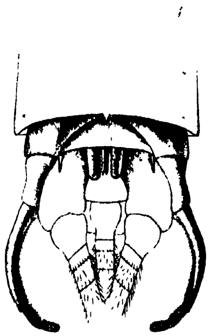

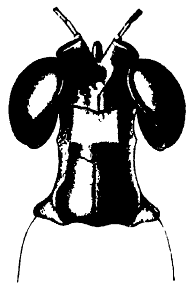

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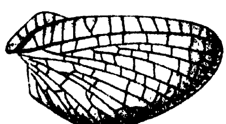

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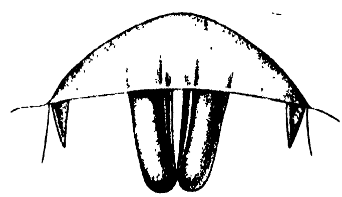

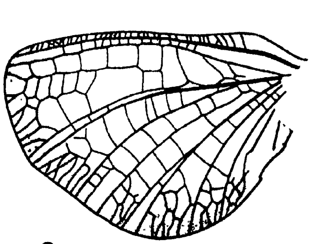

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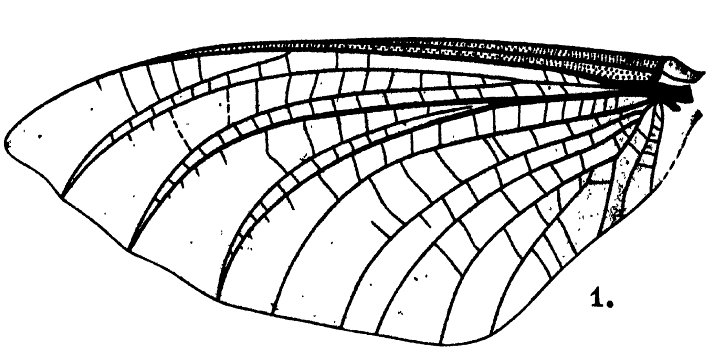


3.

1.

EXPLANATION OF PLATE V.

Ephemera annandalei Chopra, sp. nov.

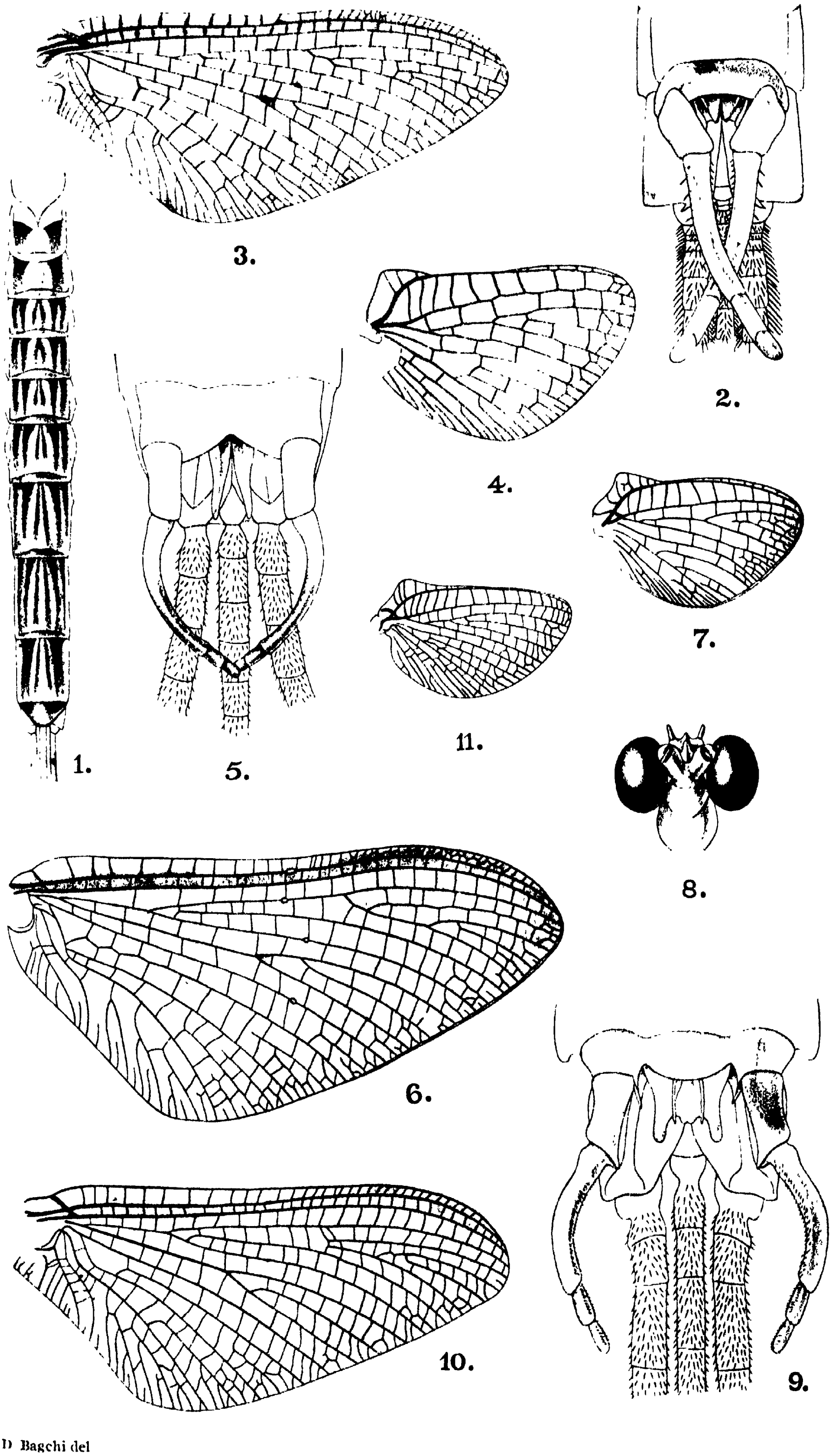
FIG. 1.—Abdomen of male, dorsal view : × 9.
FIG. 2.—Genitalia of male, ventral view : × 30.
FIG. 3.—Forewing of male : × 6.
FIG. 4.—Hindwing of male : × 10.

Ephemera supposita Eaton.

FIG. 5.—Genitalia of male : × 28.
FIG. 6.—Forewing of male : × 6.
FIG. 7.—Hindwing of male : × 5.

Ephemera immaculata Eaton.

FIG. 8.—Head and prothorax of male, dorsal view : × 10.
FIG. 9.—Genitalia of male, ventral view : × 45.
FIG. 10.—Forewing of male : × 8.
FIG. 11.—Hindwing of male : × 8.



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NOTES ON *NEVADNE GLAUCA* (ANNANDALE).

By N. KESAVA PANIKKAR, *M. A., D. Sc.*

(From the University Zoological Laboratory, Madras.)

INTRODUCTION.

In 1915, Annandale (1) described a rare anemone from the Chilka Lake as a new species of the genus *Gyrostoma* belonging to the family Actiniidae. The numerous differences between this species, *Gyrostoma glaucum*, and the other members of the Actiniidae were pointed out by Stephenson (6) who in his papers on Actinian classification assigned Annandale's species to a new genus *Nevadne*, and placed it in the Endomyarian family Myonanthidae, constituted of the genera *Myonanthus*, *Macrodactyla*, *Boloceroides* and *Nevadne*. Later investigations by Carlgren (2) showed that this family could be dispensed with since *Myonanthus* and probably *Macrocactyla* were really Actiniid genera, while *Boloceroides* was in many respects a primitive form requiring a separate place in classification. A new sub-tribe, Boloceroidaria, was constituted by him for *Boloceroides* and *Bunodeopsis* since these genera included forms without basilar muscles but at the same time having a well developed longitudinal ectodermal musculature on the wall of the column and feebly developed retractor muscles on the mesenteries. On re-examination of Annandale's type specimen of *Gyrostoma glaucum*, Carlgren (3) discovered some of the Boloceroidarian features in the anemone, like, for example, the ectodermal longitudinal musculature of the body wall. On the basis of this, he provisionally referred the genus to the Boloceroidaria, under an independent family, the Nevadneidae. A very peculiar arrangement of tentacles that involves an atypical mode of development of the later sets of micromesenteries and tentacles was also reported by Carlgren as a result of his detailed examination of a sextant of the oral disc. In view of the peculiarities in the tentacular arrangement and of the many gaps in our knowledge of *Nevadne glauca*, a thorough re-investigation of the species is highly desirable ; but this would be possible only if the anemone is rediscovered. The following observations are based on a single specimen (one of the type series) from the Indian Museum, kindly lent me from the collections of the late Dr. Annandale. I wish to thank Dr. Baini Prashad for the loan of this interesting and rare material and Prof. Gopala Aiyar for valuable help and suggestions.

I have examined one of the specimens labelled ZEV 6825/7. After carefully noting the external characters, the anemone was cleared in Turpineol, and the arrangement of mesenteries and their relationship with the different cycles of tentacles were followed as far as possible under the binocular. The anatomy was studied from serial transverse sections of the same anemone, stained in Heidenhain's Haematoxylin and Orange G. The preservation of the material being indifferent, the histological details could not be followed in detail.

EXTERNAL CHARACTERS.

The specimen is vase-shaped and evidently in a state of contraction. The measurements are as follows :—

Total length of the column	9 mm.
Diameter of the basal disc	3 mm.
Maximum width of the column	5 mm.
Diameter of the oral disc	4 mm.
Average length of tentacles—	
(*a*) Outer	14 mm.
(*b*) Inner	6 mm.

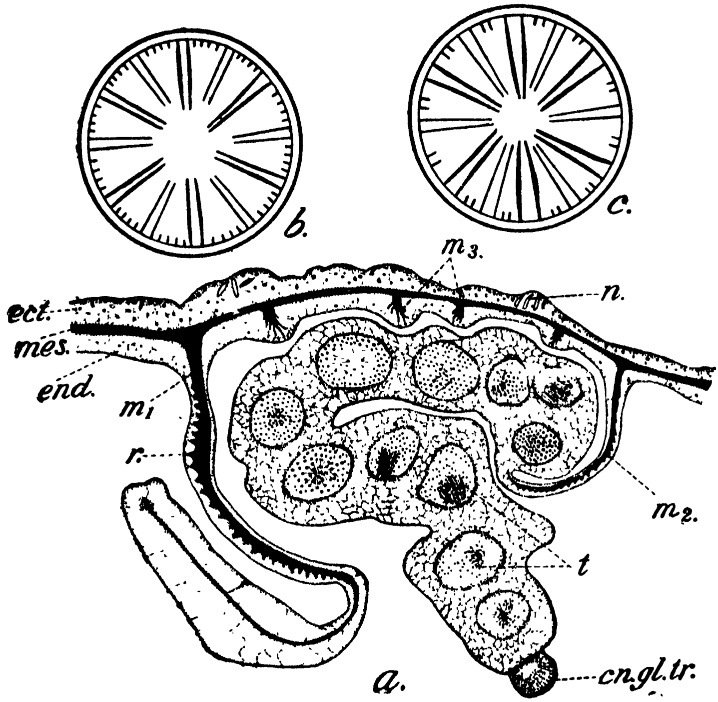
The basal disc is distinct and is provided with a distinct minute aperture in the centre. Annandale has described this as a distinct aboral pore characteristic of the species, but I doubt if this is a constant feature. As is frequently the case with young Actiniaria and certain Ceriantharia, these openings are not permanent structures, but are only punctures caused by sudden contractions. Basilar muscles are definitely absent. Insertions of the first and second cycles of mesenteries are clearly visible on the basal disc.

The column is broader at the distal part than at the proximal, and is narrowest just below the oral disc. The microscopic prominences described by Annandale are indistinguishable in the specimen, but the nematocysts on the column are arranged in groups as also noticed by Carlgren (**3**). The wall of the column is thin, and insertions of the mesenteries and their relationship with the tentacles are easily made out through the column of the cleared specimen. Columnar sphincter appears to be absent, but I have not been able to verify this from longitudinal sections of the anemone. Carlgren has already noted the presence of ectodermal longitudinal musculature on the column. In the specimen investigated by me, this muscle layer is absent from the column except in the upper region near the oral disc where it is quite distinct; but even here the musculature is rather feeble in comparison with that of other Boloceroidaria. However, these muscle fibres are quite clear at the portion of the column adjacent to the outermost row of tentacles; and it must have been this feature that led Carlgren to remark that they are rather well developed at the distal part of the column.

The Oral Disc is narrow and crowded with tentacles, there being no distinct margin. The throat is not open and has three or four faint throat ridges discernible on either side of the mouth.

The tentacles of the specimen examined number 78, which is considerably lower than the full quota of 144, described by Annandale and Carlgren. Among the 78, six are rather very small and obviously belong to cycles that have just begun to appear. Among the remaining 72, a set of 24 outermost tentacles can easily be distinguished as they are the largest in the anemone. The next in size is a set of six tentacles situated just adjacent to the mouth and evidently belonging to the primary cycle. Another set of six smaller tentacles is observed outside them, these being the tentacles of the second cycle. The remaining cycles are arranged between the latter and the last cycle of outermost tentacles. Based upon Annandale's remarks and his own examination

of the type specimen, Carlgren has found that the tentacular formula for the species is 6+6+12+48+48+24. This fact goes to prove that the specimen examined by me is one that has not attained the final stage in tentacular arrangement.



Anatomy of *Nevadne glauca* (Annandale).

a. Part of a transverse section passing through the column of *Nevadne glauca*, showing one primary mesentery, one secondary mesentery bearing gonad, and four tertiary mesenteries (× 300); *b.* Scheme of arrangement of the mesenteries at the distal-most part of the column, showing the 24 pairs of tertiary mesenteries; *c.* Scheme of arrangement of mesenteries on the column, somewhat below the oral disc, where only twelve pairs of tertiary mesenteries are visible. The primary mesenteries are shaded a little darker than the secondaries, while the tertiaries are represented as very small septa.

cn. gl. tr. cnidoglandular tract; *ect.* ectoderm of the column; *end.* endoderm of the column; *mes.* mesoglea; *m1.* primary mesentery; *m2.* fertile secondary mesentery; *m3.* tertiary mesenteries, four of them occurring between adjacent pairs of primary and secondary mesenteries; *n.* nematocysts; *r.* retractor; and *t.* testes.

The tentacles are without basal sphincters of the type noted for the Boloceroididae. The longitudinal musculature of the tentacles and the radial musculature of the oral disc are ectodermal, and are well developed.

ANATOMY.

The actinopharynx extends to about half the length of the column. There are two siphonoglyphs with aboral prolongations which are associated with two pairs of directive mesenteries. The musculature of the stomodaeum is weak.

The arrangement of the mesenteries is indicated in text figures *a*, *b* and *c*. There is no sharp distinction into macrocnemes and microcnemes. In all there are three cycles of mesenteries, consisting of a primary and a secondary cycle each with six pairs of septa, and a tertiary group of twenty-four mesenteries. Only the first and second cycles extend to the aboral extremity of the column, the last cycle of mesenteries being seen only near the oral disc. In each exocoel between one primary and secondary pair of septa, four mesenteries belonging to the last set are seen in sections of the upper-most part of the column. As pointed out by Carlgren, there is thus a doubling of the youngest cycle of mesenteries in this specimen also; but there is this important difference that the doubling of mesenteries occurs in the fourth cycle in his specimen, while in the present individual, the doubling is in the third cycle. This fact is of considerable importance as it would mean that the deviation in the development of micro-mesenteries and tentacles commences even with the appearance of the third cycle of mesenteries. The relationships of the different cycles of mesenteries with the tentacles are as follows: The endocoels of the primary mesenteries are in communication with the innermost cycle of tentacles. The second cycle of tentacles belongs to the endocoels of the secondary mesenteries. The two pairs of mesenteries that lie in each exocoel between the pairs of primary and secondary septa are in communication with two endocoelic tentacles which are situated between the outermost group of large tentacles and those belonging to the inner group of endocoelic tentacles composed of the first and second cycles. Between each pair of endocoelic tentacles belonging to the third cycle, a single small exocoelic tentacle is seen in most sextants; in others they are not observed, probably not being developed. The largest outermost set of twenty-four tentacles is also exocoelic.

Of the two pairs of mesenteries found in each exocoel between the first and second cycles of mesenteries, one pair is always found to be younger than the other as could be judged from the degree of development of the mesenteries and the extent to which they traverse the length of the column. Hence, in sections taken a little below the disc where the mesenteries of the first, second, and third cycles are found, only two mesenteries are seen between any two pairs of primary and secondary mesenteries (text figure *c*.). As we proceed higher up, the two other mesenteries make their appearance, thus making the full complement of four (*cf.* text figures *b* and *c*.). Hence, the mesentrial arrangement throughout the anemone, except where the last-mentioned younger mesenteries are found, is such as to suggest a normal condition, involving the six primary, six secondary, and twelve tertiaries. A parallel condition is also found in *Phytocoeteopsis ramunnii* described by me in a previous paper (**4**), where the doubling of later sets of micromesenteries and the attendant irregularities in arrangement could be noticed only near the oral disc of the anemone, the other regions of the column presenting the normal condition.

The primary mesenteries are provided with feeble retractors which have only a few muscle folds. Parietal muscles are absent. The secondary mesenteries attain almost the same amount of development as

the primaries, but the tertiaries are very weak. Mesenterial filaments are found on the mesenteries of the first and second cycles, and are absent from those of the third. The ciliated tracts of the filaments appear to be very short as only the cnidoglandular tract traverses the major portion of the mesenteries.

Annandale has observed the reproductive organs borne by the mesenteries of the second order as shown clearly by his figure of a section passing through an anemone (Figure 1, p. 71). The specimen studied by me is a male having well developed testes on some of the mesenteries, and containing spermatozoa in numerous chambers (text figure *a*.). The mesenteries belonging to the second cycle are provided with gonads, while the last cycle is completely sterile. The same is true of all the mesenteries of the first cycle except one which shows traces of gonads.

So far as could be ascertained from sections, spirocysts appear to be absent from the column, while a large number of nematocysts are arranged in groups. The capsules are of the usual type and are slightly curved. The spirocysts and nematocysts occur in great abundance on the tentacles. I am unable to make out the different types of capsules, but their measurements taken from sections are given below.

	L. B. (In Microns).
Nematoysts of the column (Majority Capsules).	12-18×2·5-3·0
Nematocysts of the tentacles—	
(1)	22-26×3·0
(2)	14-18×2·0
Spirocysts of the tentacles	25-28×3·0
Nematocysts of the throat	16-18×2·0
Nematocysts of the filament	20-22×3·0

REMARKS.

This re-investigation is in some respects incomplete in as much as certain points of structure are left unsettled owing to lack of sufficient material. Definite data have, however, been brought forward relating to the absence of basilar muscles on the pedal disc, and the structure of the column, actinopharynx, and the mesenteries. Of these the first feature definitely settles the unmistakable Athenarian character of the anemone, which along with the presence of longitudinal ectodermal muscles on the body-wall confirms its position in the Boloceroidaria. The distribution of the gonads and the presence of siphonoglyphs are in comformity with the views expressed in my paper on *Boloceractis* (5), where I have endeavoured to link up *Nevadne* to the Boloceroididæ, through an intervening *Boloceractis*-stage. The cardinal feature of the genus *Nevadne* is the doubling of the last set of micromesenteries and tentacles, involving an atypical mode of development of later orders which, as Carlgren has pointed out, is a marked deviation from what is found in all other Actiniaria. A similar peculiarity has also been noticed in *Phytocoeteopsis* (4); in both cases, there is reason to believe that there is a regular zone of growth where new tentacles appear and remain as interpolated structures, disturbing the original arrangement which otherwise would be quite normal. A detailed comparison of

the conditions in *Nevadne* and *Phytocoeteopsis* is being made in another study dealing with the development of the later sets of micromesenteries and tentacles in *Phytocoeteopsis ramunnii.*

The structural differences between the specimen described by Annandale and by Carlgren, and that which I have examined, are worthy of note since they seem to point to a reasonable doubt as to whether the present individual is conspecific with *Nevadne glauca*, in spite of its being labelled by Annandale as *Gyrostoma glaucum*. There is agreement between the two in all the main features excepting the absence of the 4th cycle of mesenteries and the presence of gonad in one of the primary mesenteries in my example. The cycle of mesenteries that has undergone doubling in this instance is the 3rd, while in the type specimen this occurs in the 4th cycle consisting of 48 septa. Do these characters necessitate the formation of a separate species for this anemone ? The last mentioned character is of much significance and would easily have marked off the anemone as belonging to a different species but for the fact the specimen does not seem to have reached its final stage of growth as judged by the nature of the mesenteries and tentacles. Further, the sizes of cnidae from different regions of this specimen are found to be in close agreement with those given by Carlgren. In view of these facts, I have described it as *Nevadne glauca*. The anemone is certainly a member of the genus *Nevadne*, but whether it is merely a developmental stage of *Nevadne glauca* or an almost adult stage of another closely related species cannot finally be settled until other specimens are investigated and the problem of the order of succession of later septa in the genus is subjected to a closer scrutiny.

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FURTHER NOTES ON CRUSTACEA DECAPODA IN THE INDIAN MUSEUM.

IX. On Three Collections of Crabs from Tavoy and Mergui Archipelago.

By B. Chopra, *D.Sc., F.N.I., Assistant Superintendent, and* K. N. Das, *M.Sc., Assistant, Zoological Survey of India, Calcutta.*

(Plate VI.)

The present report deals with three collections of crabs, two made by Prof. F. J. Meggitt of the University College, Rangoon, mostly at Maungmagan on the Tavoy Coast of Burma and the third by Drs. B. Prashad and B. N. Chopra of the Zoological Survey of India in the Mergui Archipelago. In the first collection of Prof. Meggitt, made in October 1933, there are also some specimens labelled " Mergui " ; these were presumably collected in the neighbourhood of the town of Mergui. The second collection of Prof. Meggitt was made entirely at Maungmagan in October 1935, while the Mergui collection of Drs. Prashad and Chopra was made in January this year.

Maungmagan is a small village on the Tavoy Coast in Lower Burma, north-west of the town of Tavoy (14° 15′ N., 97° 50′E.), and is, on account of its fine sandy beach, a popular sea-bathing resort. A sketch-map of the sea coast at Maungmagan, supplied by Prof. Meggitt, showing the exact location of the rock pools, sandy pools, etc., has already been published by Hora and Mukerji[1] with their account of the fishes of Prof. Meggitt's collection.

The collection from the Mergui Archipelago is chiefly from the group of small islands on the south-west and west of King Island, mostly between it and the large, more or less unsurveyed, Doung Island (or Ross Island, as it is also called). For the most part the collection was made from submerged coral reefs, but several specimens were collected on the beach at low tide also.

A list of the species found in all the three collections is given below and the species found in each collection are separately indicated. The species collected either only at Mergui or both at Mergui and Maungmagan and included in Prof. Meggitt's first collection are marked " M". An asterisk before the name of a species indicates that this was not represented in Dr. J. Anderson's collection from the Mergui Archipelago (*vide infra* p. 380).

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[1] Hora and Mukerji, *Rec. Ind. Mus.* XXXVIII, p. 16 (1936).

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		Prof. Meggitt's first collection from Mergui and Maungmagan.	Prof. Meggitt's second collection from Maungmagan.	Drs. Prashad and Chopra's collection from Mergui Archipelago.
Oxystomata.				
Calappidae.				
Calappinae.				
**Calappa hepatica* (Linn.)	... ...	+M	—	—
Matutinae.				
**Matuta lunaris* (Forskål)	... ...	+M	+	—
**Matuta planipes* Fabricius	... ...	—	+	—
Leucosiidae.				
Leucosiinae.				
**Heteronucia mesanensis* Rathbun	... ...	—	—	+
Philyra scabriuscula (Fabricius)	... ...	+	—	—
Brachygnatha.				
Oxyrhyncha.				
Maiidae.				
Pisinae.				
Hyastenus hilgendorfi de Man	... ...	—	—	+
Hyastenus sp. ...	... ...	—	—	+
Maiinae.				
Schizophrys asper (M.-Edw.)	... ...	+M	—	+
Parthenopidae.				
Parthenopinae.				
**Oethra scruposa* (Linn.) ...	... ...	+M	—	—
Brachyrhyncha.				
Portunidae.				
Carcininae.				
**Carcinus maenas* (Linn.)...	... ...	+	—	—
Lupinae.				
**Scylla serrata* (Forskål) ...	... ...	+M	+	—
**Neptunus* (*Neptunus*) *sanguinolentus* (Herbst)	...	—	+	—
Charybdis (*Goniosoma*) *cruciata* (Herbst).	...	—	+	—
**Charybdis* (*Goniosoma*) *lucifera* (Fabricius)	...	+M	—	—
**Charybdis* (*Goniosoma*) *annulata* (Fabricius)	...	—	+	—
Charybdis (*Goniosoma*) *merguiensis* (de Man)	...	+	+	—
**Charybdis* (*Goniosoma*) ? *callianassa* (Herbst)	...	+	—	—
Thalamita prymna (Herbst)	... ...	—	+	—
Xanthidae.				
Xanthinae.				
**Carpilodes margaritatus* A. M.-Edw.	...	—	—	+
Atergatis integerrimus (Lamarck)	... ...	+M	—	—
**Xantho neglectus* Balss	... ...	+M	+	—
Leptodius exaratus (M.-Edw.)	... ...	+	+	+
Leptodius cavipes (Dana)	... ...	+	—	—
Actaeinae.				
Actaea areolata Dana ...	... ...	—	—	+
**Actaea calculosa* (M.-Edw.)	... ...	—	—	+
Chlorodinae.				
Chlorodiella niger (Forskål)	... ...	—	—	+
**Cymo melanodactylus* de Haan	... ...	—	—	+
Menippinae.				
Menippe rumphii (Fabricius)	... ...	+	+	—
Myomenippe hardwickii (Gray)	... ...	—	—	+

	Prof. Meggitt's first collection from Mergui and Maungmagan.	Prof. Meggitt's second collection from Maungmagan.	Drs. Prashad and Chopra's collection from Mergui Archipelago.
Ozinae.			
Epixanthus frontalis (M.-Edw.)	—	—	+
Pilumninae.			
Pilumnus longicornis Hilgendorf	—	—	+
**Pilumnus hirsutus* Stimpson	—	—	+
Actumnus elegans de Man.	—	—	+
Eriphinae.			
Trapezia cymodoce (Herbst)	—	—	+
**Trapezia ferruginea*, var. *areolata* Dana ...	—	—	+
**Tetralia glaberrima* (Herbst)	—	—	+
Gonoplacidae.			
Pseudorhombilinae.			
**Litocheira angustifrons* Alcock	—	—	+
Potamonidae.			
Potamoninae.			
**Potamon* (*Acanthotelphusa*) *dayanum* (W.-M.) ...	+	—	—
Potamon sp.	+	—	—
Gecarcinucinae.			
Paratelphusa (*Phricotelphusa*) *callianaria* (de Man)	—	—	+
Ocypodidae.			
Ocypodinae.			
Ocypoda ceratophthalma (Pallas)	—	+	—
**Ocypoda macrocera* M.-Edw.	+	+	—
Ocypoda cordimana Desmarest	—	+	—
Gelasimus triangularis A. M.-Edw.	—	—	+
**Gelasimus marionis* (Desmarest)	—	—	+
Gelasimus manii (Rathbun)	+	—	+
Scopimerinae.			
Dotilla intermedia de Man	+	—	—
Macrophthalminae.			
**Macrophthalmus telescopicus* (Owen) ...	—	—	+
**Macrophthalmus convexus* Stimpson	+	—	—
Macrophthalmus erato de Man	—	—	+
Grapsidae.			
Grapsinae.			
Grapsus strigosus (Herbst)	+	+	+
Varuninae.			
**Varuna litterata* (Fabricius)	+	—	—
Sesarminae.			
Sesarma (*Sesarma*) *taeniolata* White... ...	+	—	—
**Sesarma* (*Parasesarma*) *prashadi*, sp. nov. ...	—	—	+
Sesarma (*Chiromantes*) *bidens* (de Haan) ...	+	—	+
Clistocoeloma merguiense de Man	—	—	+
Metaplax dentipes (Heller)	+	–	+

It will be seen from this list that of the total number of 57 species in all the three collections there are 26 in the first collection (of which 8 are from Mergui), 15 in the second and 30 in the third. These 57 species

belong to 10 families and are distributed in the three collections as shown below :—

Family.	Number of species in each collection. I	II	III	TOTAL.
Calappidae	2	2	..	3
Leucosiidae	1	..	1	2
Maiidae	1	..	3	3
Parthenopidae	1	..	..	1
Portunidae	5	6	..	9
Xanthidae	5	3	14	18
Gonoplacidae	..	..	1	1
Potamonidae	2	..	1	3
Ocypodidae	4	3	5	10
Grapsidae	5	1	5	7
TOTAL .	26	15	30	57

Of the 57 species dealt with by us there are only eight that occur both on the Tavoy Coast and in the Mergui Archipelago ; these are listed below. The apparent difference in the composition of the crab-fauna of these two, more or less adjacent areas can perhaps be easily explained by the fact that the collections in the two localities were made in different types of habitats. At Maungmagan Prof. Meggitt obtained most of his material from pools near shore, from under rocks near shore, or from the sandy beach ; this would no doubt account for large numbers, at least of individuals, if not of species, of Portunids, Oxystomes, Grapsids, etc., being collected. The collections from the Mergui Archipelago, on the other hand, were made, to a large extent, in coral reefs where certain types of Xanthids are abundant.

List of species found both at Maungmagan and Mergui.

Calappidae.
Matuta lunaris (Forskål).

Portunidae.
Scylla serrata (Forskål).

Xanthidae.
Xantho neglectus Balss.
Leptodius exaratus (M.-Edw.)

Ocypodidae.
Gelasimus manii (Rathbun).

Grapsidae.
Grapsus strigosus (Herbst).
Sesarma bidens (de Haan).
Metaplax dentipes (Heller).

The Decapod fauna of the Mergui Archipelago is already very well known, for, besides the work of earlier naturalists, de Man's monograph on[1] the Decapods of this area, based on the very extensive collections of Dr. J. Anderson, the first Superintendent of the Indian Museum, is a very comprehensive and masterly treatise on the subject.

[1] de Man, *Journ. Linn. Soc. London (Zool.)* XXII, pp. 1-312, pls. i-xix (1887, 1888).

Dr. Anderson's collections were so extensive that in crabs alone de Man found as many as 115 species, compared with the 57 that we have before us. Another proof of the extensiveness of Dr. Anderson's collection is the fact that out of our 57 species only one is described as new. The species that were not represented in the collection that de Man examined, but are present in our collection are indicated in the list on pp.378,379 by an asterisk. Most of these species have been collected in the Mergui Archipelago or from closely adjoining areas since de Man's time, but so far as we have been able to ascertain the following five species are being recorded from this area for the first time :—

Leucosiidae.
Heteronucia mesanensis Rathbun.
Portunidae.
Carcinus maenas (Linn.).
Xanthidae.
Carpilodes margaritatus A. M.-Edw.
Gonoplacidae.
Litocheira angustifrons Alcock.
Grapsidae.
Sesarma (Parasesarma) prashadi, sp. nov.

The occurrence of these species in the Mergui Archipelago does not call for any special comments, for most of them have also been collected from other parts of the Indo-Pacific region. The case of *Carcinus maenas*, however, deserves special consideration. Alcock[1] described the distribution of this crab as : " The species has been found at various places on the Atlantic Coast of the Northern United States and off the coast of Pernambuco (Brazil) : it is the common shore-crab of the British Islands, and occurs in the North Sea almost up to the Arctic limits, in the Baltic, and on the Atlantic coasts of the European continent : it is common in all parts of the Mediterranean, and has been found in the Black Sea and the Red Sea : it is an Indian species, though evidently a very rare one, and has been reported from the Hawaiian Islands, from the Bay of Panama, and—though there is doubt about this locality—from Australia." In the Indian waters the species has been recorded from Ceylon only. Some of the records of this cosmopolitan species from the Indo-Pacific region have been doubted by some carcinologists ; its occurrence on the Tavoy coast definitely establishes the species as an inhabitant of at least the eastern part of this area. Hora and Mukerji[2] have recently recorded from Tavoy some species of fishes that were so far supposed to live in the European Atlantic only ; the distribution of *Carcinus maenas*, as indeed of a large number of other species of marine animals enumerated by Alcock,[3] suggests that the occurrence of some Atlantic fishes in the Indian waters is not so very singular as has been supposed by some Zoologists.

In working out the present collections several interesting points concerning either the taxonomy of certain species or their distribution,

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[1] Alcock, *Journ. As. Soc. Bengal* LXVIII, p. 14, (1899).
[2] Hora and Mukerji, *Rec. Ind. Mus.* XXXVIII, pp. 15-39 (1936).
[3] Alcock, *Investigator Deep-Sea Madreporaria, Calcutta (1898) ; Investigator Deep-Sea Brachyura, Calcutta (1899).*

etc., have arisen; these are dealt with in their appropriate places in the following pages, and need not be referred to here. In the classification and arrangement of species we have closely followed Alcock's system as given in his masterly treatment of the Indian crabs in the series of papers entitled "Materials for a Carcinological Fauna of India" and published in the *Journal of the Asiatic Society of Bengal* between 1895 and 1900. In the Xanthidae Dr. Heinrich Balss and some other carcinologists have considerably altered Alcock's classification, but for the present at least we have preferred to follow Alcock's arrangement of subfamilies, etc. We have not given anything like complete synonymies of species, but have given a reference to Alcock's work and in some cases a few later important references only.

We have paid special attention to a study of the abdominal appendages of the male as these structures sometimes afford good characters for distinguishing males of closely allied species, and for this reason we have given figures of these appendages in a large number of species dealt with by us.

The illustrations accompanying this paper have been prepared, under our supervision, by Babu D. N. Bagchi and Babu Subodh Mondul, two of the talented artists attached to the Zoological Survey of India; both of them are jointly responsible for the text-figures, while the photographs are the work of Babu Subodh Mondul alone. We are very thankful to them for the skill and accuracy with which they have done the work. We would also like to express our special indebtedness to Dr. Baini Prashad, Director, Zoological Survey of India, for constant help and valuable suggestions received throughout the course of our work and for going through the manuscript with us. And lastly we have to express our thanks to Prof. F. J. Meggitt for giving us the opportunity to study his valuable collections.

Tribe OXYSTOMATA.

Family CALAPPIDAE.

Subfamily *CALAPPINAE.*

Calappa hepatica (Linn.).

1896. *Calappa hepatica,* Alcock, *Journ. As. Soc. Bengal* LXV, pp. 142-144.
1918. *Calappa hepatica,* Ihle, *Siboga Exped. Rep.* XXXIXb^2, pp. 183, 184.
1922. *Calappa hepatica,* Balss, *Arch. Naturgesch.* LXXXVIII, p. 123.
1936. *Calappa hepatica,* Sakai, *Sci. Rep. Tokyo Bunrika Daigaku* (B) II, No. 37, p. 157.

One young specimen referable to the present species is in Prof. Meggitt's first collection from Mergui. The specimen is typical in every respect.

Calappa hepatica has a very wide range of distribution. Ihle gives its range as the Red Sea and the East African Coast to Japan, Australia and Sandwich Islands. In the Indian Museum there are numerous specimens both from the Bay of Bengal and the Arabian Sea.

Subfamily *MATUTINAE.*

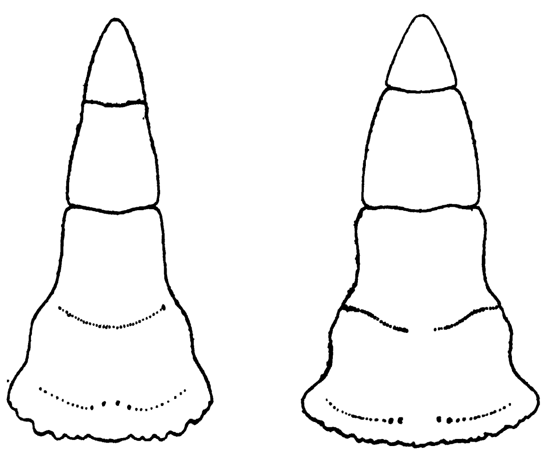
Matuta lunaris (Forskäl).

1896. *Matuta victor*, Alcock, *Journ. As. Soc. Bengal* LXV, pp. 160, 161.
1933. *Matuta lunaris*, Chopra, *Rec. Ind. Mus.* XXXV, pp. 31, 32.

There is a large number of specimens of the present species in the two collections of Prof. Meggitt. Only one of these specimens is from Mergui, while all the rest are from Maungmagan; of the latter some were collected from rock pools near shore, some from fisher-boat nets, and the others at Cat's Eye Rocks. The specimens are for the most part typical.

Two of the most important characters mentioned by Alcock for the separation of this species from the closely allied *M. planipes* (=*M. lunaris* of Alcock) are the presence in large males, of a spine at the angle where the hand comes in contact with the distal lobule of the arm and the presence, in females and young males, of two enlarged spines (counting from the proximal end, the second and the fourth) on the median longitudinal ridge on the outer surface of the hand. In *M. planipes* the spine at the angle of the hand is replaced by a tubercle, and the fourth lobe of the median longitudinal ridge of the hand is never enlarged into a spine. In all the specimens that we have examined in the present collection the spine near the junction of the arm is well developed; the fourth spine on the median longitudinal ridge is present in all the females and in most of the very young males; while in all medium-sized and large males this spine is invariably missing.

In addition to the characters mentioned by Alcock, the males of the two species can be generally recognised by the shape of the abdomen.



a. *b.*

TEXT FIG. 1.—Terminal part of male abdomen of *a. M. lunaris*: × *ca.* 3 *b. M. planipes* : × 3½.

The abdomen in the males of *Matuta* consists of five pieces only, segments 3-5 being completely fused. In *M. lunaris* the length of the composite segment 3-5 is always greater than its breadth at the base,

and the terminal segment is always considerably longer than its posterior breadth. In *M. planipes*, on the other hand, the length of the composite segment is at most equal to, but generally less than, its breadth at the base and the last segment is almost as long as, or only slightly longer than, its posterior breadth. The sixth segment is also proportionately longer in *M. lunaris* than in *M. planipes*. These points are brqught out clearly in text-figure 1 and the table of measurements.

	M. lunaris.	*M. planipes.*
Posterior breadth of composite segment 3-5	9·5	9·0
Median length of composite segment 3-5	10·8	9·0
Posterior breadth of segment 6	4·2	4·2
Median length of segment 6	5·0	4·4
Posterior breadth of segment 7	2·7	2·7
Median length of segment 7	4·0	2·9

The colour pattern of the species, mentioned by Alcock, is clearly seen only in some specimens.

Matuta lunaris has a very wide range of distribution having been recorded from several localities from Polynesia in the east to as far as the Red Sea and the Cape region on the west. In India it has been collected both in the Bay of Bengal and the Arabian Sea.

Matuta planipes Fabricius.

1896. *Matuta lunaris*, Alcock, *Journ, As. Soc. Bengal* LXV, pp. 161, 162.
1933. *Matuta planipes*, Chopra, *Rec. Ind. Mus.* XXXV, p. 32.
1936. *Matuta flagra*, Shen, *Chinese Journ. Zool.* II, pp. 64-66.

The species is represented in the present collection by five examples, two females and three young males, obtained by Prof. Meggitt from fisher-boat nets at Maungmagan.

Alcock has described a distinctive colour pattern in this species, which can sometimes be seen in very old specimens also. In the present collection this colour pattern is distinctly seen in one female example only; in the second female and the three males there is practically no colour pattern at all.

The male specimens are for the most part without claws, but in the claws that are present the typical *planipes* characters can be seen—at the angle near the arm there is only a somewhat low tubercle, and not a spine, as in the preceding species, and there is only one enlarged spine, the second from the proximal end, on the median longitudinal ridge on the outer surface of the hand. One of the females, with the distinct *planipes* colouration, also shows these characters clearly, but the second female has the typical *planipes* claw only on one side; in the other claw there is a sharp tubercle on the hand near its junction with the arm, and the fourth tubercle on the median ridge is also spiniform. This seems to be a rare abnormality, for a condition like this is not present in any of the large number of specimens of this species in the Indian Museum collection.

The species recently described by Shen under the name of *M. flagra* seems to be based on young specimens of the present species. The characters of the hand mentioned by him agree almost exactly with those of young examples of *M. planipes* that we have examined. Shen

has also mentioned that the epibranchial spines in his species are directed straight outwards, instead of curving forwards as in *M. lunaris* (=*M. victor* of Alcock). We have examined a large number of specimens of both the allied species, *M. lunaris* and *M. planipes* and find that this character is far from constant. The spines are sometimes curved forwards, sometimes they point straight outwards, while in some cases they are directed distinctly backwards even. The smoothness of the outer surface of the movable finger of the hand is, as pointed out by Alcock for his *M. victor*, a character of the young; this is equally applicable to the young of the present species also. The colour pattern of the species, as already pointed out, is variable. From all these considerations we are of the opinion that Shen's *M. flagra* cannot be maintained as a distinct species, but must be sunk in the synonymy of *M. planipes* Fabricius.

Like the preceding species, *M. planipes* has a very wide range of distribution, having been met with from North-West of Australia in the east to the Cape of Good Hope in the west.

Family LEUCOSIIDAE.

Subfamily *LEUCOSIINAE*.

Heteronucia mesanensis Rathbun.

(Plate VI, fig. 1).

1910. *Heteronucia mesanensis*, Rathbun, *Skrift. K. Dansk. Vidensk. Selsk. Copenhagen* (7) V, pp. 306, 307.

1918. *Heteronucia mesanensis*, Ihle, *Siboga Exped. Rep.* XXXIXb^2, p. 309 (reference only).

One small female specimen from Mergui is referred to Miss Rathbun's species with some hesitation. In a general way our specimen agrees closely with the brief description published by Miss Rathbun, but in view of some important differences between the two, as pointed out below, we have thought it worth while giving a full description of our specimen.

The carapace (Plate VI, fig. 1) is subcircular in outline, it is strongly convex and its surface is markedly uneven on account of the prominent convexities of the different regions. The entire surface of the carapace, chelipeds and legs is covered with vesiculous granules closely studded together. The regions of the carapace are clearly demarcated by convexities, separated from one another by broad shallow grooves. The narrow triangular area embracing the mesogastric and the anterior part of the cardiac regions, mentioned by Miss Rathbun, is clearly seen, but is bordered by only shallow grooves. The convexities of the gastric, cardiac and branchial regions are very distinct, there being two on the last-named region, the anterior of which is the larger of the two. There is only an inconspicuous, low tubercle on each hepatic region.

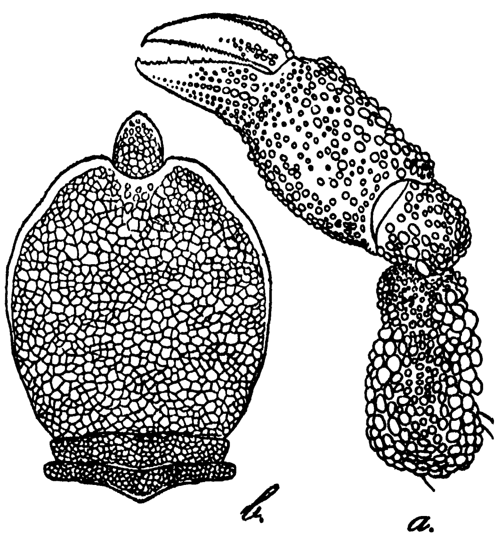
The carapace is distinctly broader than long and its lateral margins are slightly expanded. The front is broad and a narrow fissure in the middle makes it bilobed; the margin of each lobe is truncate or even slightly rounded. The pterygostomian regions are puffed out, but their anterior margin, which is almost transverse, is on a level with the eye, and when viewed from above does not extend beyond or even up to the

front. The tips of the external maxillipeds are just visible beyond the front in a dorsal view. The antero-lateral margins are divided into two subequal lobes by a rather broad and shallow notch. The postero-lateral margins are spinate, the granules near the lateral margins on the convexities of the branchial regions being sharply pointed and taking the form of short spines. The spines decrease in size distally, but extend almost up to the posterior margin of the carapace in the shape of sharply-pointed tubercles. The posterior margin of the carapace is on a lower level than the rest of the surface, and is somewhat convex posteriorly.

The orbits are shallow and do not conceal the rather large eye, even when fully retracted. Except for a narrow fissure the lower border of the orbit is practically complete, on account of the fusion of the basal antennal joint with it. The antennal flagellum has not been seen; it is either altogether missing or is very extremely reduced.

There is a remarkably broad space between the lower orbital border and the free edge of the buccal cavern. The maxillipeds completely close the buccal cavity, which is triangular in shape. Each maxilliped is strongly bent about its middle, so that the merus is nearly at right angle to ischium. Measured along the inner border the merus is only slightly more than half the length of the ischium. The exognath is quite stout, being only a little narrower than the endognath, and is straight along the outer edge.

The chelipeds are considerably stouter and longer than the walking legs and are densely covered with vesiculous granules. The arm is sub-cylinderical and is only slightly broader distally than at the proximal



TEXT FIG. 2.—*Heteronucia mesanensis* Rathbun.
a. Cheliped of female, outer view: × *ca.* 8. *b.* Abdomen of female: × *ca.* 8.

end. The wrist is globular. The palm is massive and swollen, the greatest diameter being about the middle, and the granules near its margins are sharp and pointed. The fingers are arched and taper

towards their tips, the immobile finger being distinctly more massive than the dactylus. The latter opens in a vertical plane. The fingers are shorter than the palm, their cutting edges are finely and evenly denticulated and they are hollowed and concave on the inner side. There is no gap left when the fingers meet. The tips are pointed and are apposed when the fingers meet. The fingers are also minutely granular and elegantly grooved. The lower border of the distal part of the palm and the proximal part of the fixed finger is concave.

The basal part of the walking legs is only slightly concealed beneath the lateral expansions of the carapace. The legs are also thickly covered with granules and even the dactyli are minutely granular. The merus is cylindrical, the carpus is nodular and the lanceolate dactylus is almost as long as the propodus. The granules on the margins of the different segments are sharp. The dactyli end in corneous tips.

The abdomen of the female (text-fig. 2 *b*) is large and oval and occupies practically the entire space between the legs. The exposed surface is covered with flattened granules. The two basal segments are short, the next four are completely fused and form a large broad plate. The seventh segment is a small, more or less, pear-shaped structure, somewhat deeply sunk in the distal margin of the preceding segment; its tip is rounded and reaches almost to the posterior end of the buccal cavern.

The specimen in spirit is of a pale-whitish colour, with an indistinct diffusion of light brownish tint on the carapace and a few small pale-orange spots on the ventral surface. There is a small triangular patch of a light brownish colour on the mesogastric region of the carapace.

The measurements of the specimen in millimetres (taken under a microscope) are given below.

Length of carapace	3·75
Breadth of carapace	4·50
Froto-orbital border	1·91
Length of upper border of palm	1·33
Length of dactylus	1·17

The specimen is registered in the collection of the Zoological Survey of India under the number C2283/1. It was collected by Drs. B. Prashad and B. N. Chopra from amongst corals in a submerged reef near shore, off Palaiow on the east coast of Doung Island in the Mergui Archipelago on 20th January, 1937. Miss Rathbun based the species on two female specimens collected between two islands in the Gulf of Siam at depths of 15 and 30 fathoms. As at present known the species seems to have a very restricted distribution.

Though the present specimen agrees very closely with Miss Rathbun's description of *Heteronucia mesanensis* in a large number of characters, there are some important differences between the two. The fronto-orbital border of the carapace is stated to be about half the carapace width in the Siam specimen, whereas in our example it is only about two-fifths of the breadth of the carapace. The frontal margin is faintly bidentate in Miss Rathbun's species; in the Mergui example this margin is obscurely bilobed by a narrow median fissure, the borders of each lobe being somewhat rounded. The hand in our example also differs materially from Miss Rathbun's description. The palm is thickest

about the middle and not at the proximal end, the fingers are shorter than the upper border of the palm and the dactylus is distinctly less massive than the immobile finger. The points of similarity between our specimen and Miss Rathbun's species are, however, so striking that it must, at least for the present, be referred to this species.

Heteronucia as defined by Alcock[1] is characterised, among other features, by having fingers longer than the palm, and this character is clearly seen in his figure, as also in the type-specimen of *H. vesiculosa* preserved in the Indian Museum. In *H. venusta* Nobili also, as originally described and figured by Nobili,[2] the fingers are slightly longer than the palm.[3] Besides, both these species have a peculiar type of front. In *H. mesanensis*, on the other hand, the fingers, according to Miss Rathbun, are not longer than the palm, though in her figure the palm actually appears to be somewhat longer than the fingers. In our specimen also the fingers are shorter than the palm. The front also in Miss Rathbun's species, or at least in the specimen that we are referring to it, has not the characteristic *Heteronucia* shape. It seems quite possible, therefore, that *H. masanensis* Rathbun, or at least the Mergui specimen that we have provisionally referred to this species, may have to be accommodated in a new genus.

Philyra scabriuscula (Fabricius).

1896. *Philyra scabriuscula*, Alcock, *Journ. As. Soc. Bengal* LXV, pp. 239, 240.

There are two male specimens from Maungmagan that we have referred to the present species. They bear the label "crabs on beach, sluggish: Maungmagan, 1933". The specimens agree with typical examples in the Museum collection. The dull brown and greenish mottling of the carapace, mentioned by Alcock, is not, however, visible.

The species has a very wide range of distribution. According to Ihle[4] it is met with from Amboina to the Red Sea and East Coast of Africa. In the Indian Museum there are numerous specimens from Tavoy to the Persian Gulf.

Tribe BRACHYGNATHA.

Subtribe *OXYRHYNCHA*.

Family MAIIDAE.

Subfamily *PISINAE*.

Hyastenus hilgendorfi de Man.

1895. *Hyastenus hilgendorfi*, Alcock, *Journ. As. Soc. Bengal* LXIV, pp. 209, 210.

The species is represented in the present collection by seven specimens collected in the Mergui Archipelago. Three of these are males, three

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[1] Alcock, *Journ. As. Soc. Bengal* LXV, p. 177 (1896).

[2] Nobili, *Bull. Mus. Hist. Nat. Paris* XII, p. 261 (1906); *Mem. Acad. Sci. Torino* (2) LVII, pp. 379, 380, pl. i, fig. 14 (1907).

[3] Ihle in *Siboga Exped. Rep.* XXXIXb^2, p. 320 (1918) states that the upper border of the palm in *H. venusta* is almost as long as the upper border of the dactylus, but in his figure (text-fig. 123, p. 219) the fingers are seen to be slightly longer than the upper border of the palm.

[4] Ihle, *Siboga Exped. Rep.* XXXIXb^2, p. 275 (1918).

ovigerous females and one young female. The largest male has a total length (carapace and rostrum) of over 26 mm., while the smallest ovigerous female is only 15 mm. in total length.

All the specimens agree very closely with de Man's [1] and Alcock's detailed and accurate descriptions of the species, as also with named specimens, including de Man's types from Mergui, in the Indian Museum collection. In the large male example, however, the spines are a little shorter than in the type-specimens and the fingers also gape, perhaps, a little more near the base. The proportions of the different parts of the hand are also very slightly different. As pointed out by Laurie[2] the rostral spines are longer and diverge distally more in the males than in the females. The measurements, in millimetres, of the largest male example in our collection are given below.

Total length of carapace and rostrum	26·2
Length of carapace	15·8
Distance between external orbital angles	6·5
Distance between internal orbital angles	4·5
Breadth of carapace	13·2
Length of cheliped	33·5
Length of hand and fingers	14·5
Median length of palm	10·0
Length of fingers	5·0
Height of palm	4·2
Length of first walking leg	38·0

The present specimens are registered as under :—

C2284/1.	From corals in a submerged reef near shore off Palaiow, on the east coast of Doung Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 20th Jan., 1937.	3 ♂♂, 4 ♀♀ (3 ovig.).

The species is represented in the Indian Museum collection by examples from the Straits of Malacca, Mergui, Nicobar Islands, the Ganjam coast and from Ceylon.

For reasons given by one of us in an earlier paper[3] we have retained the name of *Hyastenus* White in preference to *Halimus* Latrielle.

Hyastenus sp.

There is one young male specimen in Drs. Prashad and Chopra's collection from the Mergui Archipelago that we are unable to put in any of the known species of *Hyastenus* with any degree of certainty. The carapace is practically smooth. The gastric and the intestinal tubercles are hardly developed, while the epibranchial and the sub-hepatic tubercles are fully formed. The rostral spines are a little more than half the length of the carapace and are distinctly divergent. The dactyli of the walking legs are strongly toothed.

The specimen was collected from a submerged reef off Cantor Island in the Mergui Archipelago on 19th January, 1937.

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[1] de Man, *Journ. Linn. Soc. London (Zool.)* XXII, pp. 14-19, pl. i, figs. 3, 4 (1887).
[2] Laurie, *Ceylon Pearl Oyster Fish. Rep.* V, p. 376, (1906).
[3] Chopra, *Rec. Ind. Mus.* XXXVII, p. 467, (1935).

Subfamily *MAIINAE*.

Schizophrys asper (M.-Edwards).

1895. *Schizophrys asper*, Alcock, *Journ. As. Soc. Bengal* LXIV, pp. 243, 244; *Ill. Zool. Investigator, Crust.*, pl. xxxv, fig. 1 (1899).
1924. *Schizophrys asper*, Balss, *Arch. Naturgesch.* XC, Heft 5, p. 35.

There are three specimens of *S. asper* from Mergui in the collection. Two of these, a large male and a young female, are from Prof. Meggitt's first collection and are labelled only " Mergui," while the third, a small male, was collected by Drs. Prashad and Chopra from amongst corals in a submerged reef at Palaiow on the east coast of Doung Island in the Mergui Archipelago on January 20th, 1937. The large male from Prof. Meggitt's collection has a carapace length of 42·5 mm., while the smaller male from Doung Island is only 10 mm. long. The measurements of the larger male are given below in millimetres.

Length of carapace	42·5
Length of carapace and rostrum	50·0
Maximum breadth of carapace (excluding spines) ...	36·0
Length of chelepeds	74·0
Length of palm (including fixed finger) along lower border .	35·0
Median length of palm	23·0
Height of palm	12·0
Length of dactylus	16·5
Length of 1st walking leg	57·0

In large male examples the fingers are considerably more than half the length of the palm, and meet only at the tips, which, along with a distal part of the fingers, are channelled. In the female the chelipeds are distinctly thinner and shorter than the legs, the fingers are hardly channelled and meet throughout.

The female specimen has entangled between the legs strings of eggs of some sort arranged like bunches of grapes. The eggs are too young to be identified, only yolk granules being visible through the semi-transparent shell.

Schizophrys asper is quite a common species in the Indian coastal waters, there being specimens of it from several localities both from the Bay of Bengal and the Arabian Sea. Balss gives the distribution of the species as: " Im warmen Indopacific von der Ostküste Afrikas u. dem roten Meere bis Neu-Caledonien, Samoa u. Funafuti."

Family PARTHENOPIDAE.

Subfamily *PARTHENOPINAE*.

Oethra scruposa (Linn.).

1895. *Oethra scruposa*, Alcock, *Journ. As. Soc. Bengal* LXIV, pp. 285, 286.
1930. *Oethra scruposa*, Flipse, *Siboga Exped. Rep.* XXXIXc^2, p. 89.

One male specimen of this apparently somewhat uncommon species is in the present collection. It agrees closely with named examples in the Museum collection, as also with Alcock's description of it. The specimen is labelled " Mergui " and is from Prof. Meggitt's first collection.

There are only two examples of this species in the collection of the Indian Museum, a male from the Andamans and a female from Ceylon. The species has a fairly wide range over the Indo-Pacific area, being known from the Indian Archipelago to the east coast of Africa,

Subtribe *BRACHYRHYNCHA.*

Family PORTUNIDAE.

Subfamily *CARCININAE.*

Carcinus maenas (Linn.).

1899. *Carcinus maenas*, Alcock, *Journ. As. Soc. Bengal* LXVIII, pp. 13, 14.

Four large examples of this rare Indian species were collected by Prof. Meggitt at Maungmagan in October, 1933. All the specimens agree closely with the numerous published descriptions of the species, as also with our named material from Galle in Ceylon and from a number of other localities in the Mediterranean Sea and the North Atlantic; the specimens are typical in every respect. All the four of them are infested with Rhizocephala.

The geographical distribution of *Carcinus maenas* has already been referred to on p. 381. As stated by Alcock, it is evidently a very rare Indian species, there being only one Indian example of it (from Galle) in the Museum collection so far. The species is, however, very common in the Atlantic Ocean and the Mediterranean Sea. Alcock has discussed the distribution of this species in the work cited above, and of several other species of Crustacea and other groups in his account of the " Investigator " Madreporaria[1] and Brachyura[2]). The distribution of *Carcinus maenas* is, however, especially remarkable on account of its being a shore crab.

Subfamily *LUPINAE.*

Scylla serrata (Forskäl).

1899. *Scylla serrata*, Alcock, *Journ. As. Soc. Bengal* LXVIII, pp. 27, 28.
1922. *Scylla serrata*, Balss, *Arch. Naturgesch.* LXVIII, Heft 11, p. 110.

There are seven specimens of this common Indo-Pacific species in the present collection; three of these are in Prof. Meggitt's first collection from Mergui and four from Maungmagan in the second. All the specimens are typical.

Scylla serrata is the common edible crab of India and many other countries. In India it is met with extensively in backwaters and estuaries all along the coast. Hora[3] has described an ingenious method of its capture for market purposes in the creeks in the Gangetic Delta. The species has a very wide range of distribution all over the Indo-Pacific region; Balss gives its distribution as: " Rein indopazifisch vom Rotten Meere, der Ostküste Afrikas und dem Kap bis Japan, Australien, Tahiti und Aucklandinseln ".

Neptunus (Neptunus) sanguinolentus (Herbst).

1934. *Neptunus sanguinolentus*, Sakai, *Sci. Rep. Tokyo Bunrika Daigaku* (B) I, No. 25, p. 303.
1935. *Neptunus (Neptunus) sanguinolentus*, Chopra, *Rec. Ind. Mus.* XXXVII, pp. 474-476.

One young female example of this species is in Prof. Meggitt's second collection; it was obtained from fisher-boat nets at Maungmagan. The

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[1] Alcock. *Investigator Deep-Sea Madreporaria*, Calcutta (1898).
[2] Alcock, *Investigator Deep-Sea Brachyura*, Calcutta (1899).
[3] Hora, *Current Sci.* III, pp. 543-546 (1935).

specimen is very badly mutilated and its identification is, therefore, somewhat doubtful.

As mentioned by Chopra, *N. sanguinolentus* has a very wide range of distribution. Sakai gives Simoda as the northernmost limit of the range of the species in Japan.

Charybdis (Goniosoma) cruciata (Herbst).

1935. *Charybdis* (*Goniosoma*) *cruciatus*, Chopra, *Rec. Ind. Mus.* XXXVII, pp. 482, 483.

There are two very young specimens referable to the present species in Prof. Meggitt's second collection; these were collected from fisher-boat nets at Maungmagan. No colour markings are present on the specimens.

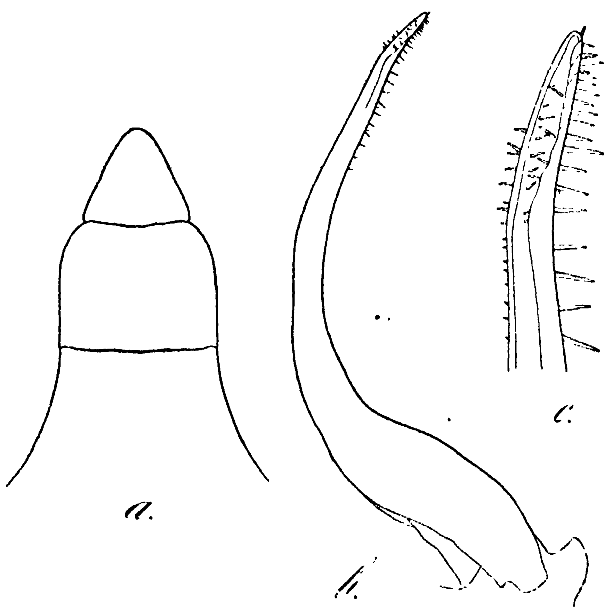
This species also, as described by Chopra, has a very wide range of distribution.

Charybdis (Goniosoma) lucifera (Fabricius).

1899. *Charybdis* (*Goniosoma*) *quadrimaculata*, Alcock, *Journ. As. Soc. Bengal* LXVIII, p. 54.

1922. *Charybdis lucifer*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 106.

A single ovigerous female, collected at Mergui, is in Prof. Meggitt's first collection. It agrees closely with named specimens in the Indian Museum collection. In some specimens from the Coromandel coast in



TEXT-FIG. 3.—*Charybdis* (*Goniosoma*) *lucifera* (Fabr.).
a. Terminal part of male abdomen: ×5. *b*. Left anterior male appendage: ×11. *c*. Tip of the same enlarged: ×34.

the Museum collection the carapace is somewhat thickly furred; the present example does not show any trace of the fur.

The sixth segment of the male abdomen has a characteristic shape.

The anterior abdominal appendages of the male are as shown in the accompanying text-figure. They are of the type usual in the genus *Charybdis*. There is no bend near the tip, and except for the fact that the small lobe on the inner border a little behind the tip is absent, the appendages are very much like those of *C. merguiensis* as figured by Chopra.[1]

C. lucifera is met with on both the coasts of the Indian Peninsula. Balss gives its distribution as: " Ceylon, Küsten von Vorderindien, Java, Malabarenküste, Siam ".

Charybdis (Goniosoma) annulata (Fabricius).

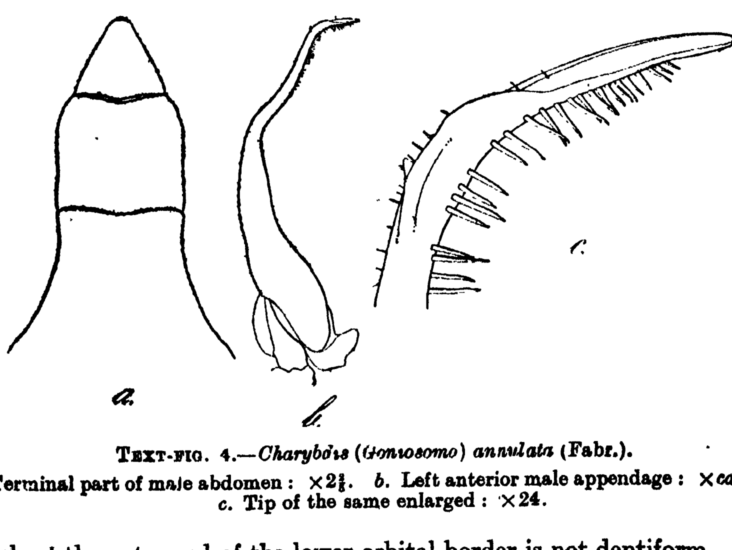
1899. *Charybdis (Goniosoma) annulata*, Alcock, *Journ. As. Soc. Bengal* LXVIII, pp. 54, 55.
1922. *Charybdis annulata*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 106.
1937. *Charybdis (Goniosoma) annulata*, Leene, *Zool. Meded. Leiden* XIX, pp. 167-168.

The following specimens referable to the present species are in Prof. Meggitt's second collection :—

C 2285/1	Maungmagan, Cat's Eye Rocks	Prof. F. J. Meggitt	1 large ♂
C 2286/1	Maungmagan Rocks : low tide	Prof. F. J. Meggitt	1 ♀, 1 small ♂

The large male has a carapace length of about 47 mm. and a breadth of 68 mm. The female is about 38 mm. long and 55 mm. broad.

C. annulata closely resembles the preceding species, but the carapace is narrower and more convex, the orbits are shorter, being about one-third of the distance between the inner supra-orbital angles, and the



TEXT-FIG. 4.—*Charybdis (Goniosoma) annulata* (Fabr.).
a. Terminal part of male abdomen : ×2⅔. *b.* Left anterior male appendage : ×*ca.* 3. *c.* Tip of the same enlarged : ×24.

lobule at the outer end of the lower orbital border is not dentiform. The sixth tergum of the male abdomen, as seen in text-fig. 4, is also longer

[1] Chopra, *Rec. Ind. Mus.* XXXVII, p. 485, text-fig. 8 (1935).

and has parallel sides. The acute spine on the posterior border of the carpus of the last leg, so characteristic of *C. merguiensis*, is absent in this species.

The anterior male appendages are of the usual type and are as shown in the accompanying text-figure. They are somewhat sharply bent near the tip. The inner margin has a small lobe-like process a little behind the tip, as in *C. merguiensis*.[1]

Most of the specimens examined have no characteristic colour-markings, but the female specimen from Maungmagan has three rather prominent purplish patches on the carapace, one on each hepatic region and a larger one on the gastric.

A few measurements in millimetres of the large male from Maungmagan are given below :—

Length of carapace	46·9
Greatest breadth of carapace	68·2
Distance between outer and inner supra-orbital angles of one side	7·3
Distance between inner supra-orbital angles	24·0

Miss Leene has shown that *Cancer fasciatus* of Herbst is not a synonym of the present species as Alcock had suggested.

C. annulata is represented in the Indian Museum collection by specimens from Penang, Bimlipatam and Karachi. The species has a fairly wide range of distribution, being known from Tahiti, Siam, Mergui Archipelago, Ceylon and the Indian coasts.

Charybdis (Goniosoma) merguiensis (de Man).

1934. *Charybdis merguiensis*, Sakai, *Sci. Rep. Tokyo Bunrika Daigaku* (B) I, No. 25, p. 303.
1935. *Charybdis (Goniosoma) merguiensis*, Chopra, *Rec. Ind. Mus.* XXXVII, pp. 484-486.
1937. *Charybdis (Goniosoma) merguiensis*, Leene, *Zool. Meded. Leiden* XIX, pp. 165-167.

This species appears to be very common at Maungmagan and is represented by 10 specimens, eight males and two females in the two collections of Prof. Meggitt. Some of the specimens are very young.

The strongly arched " Querlinie " of Monod and Steinitz is faintly indicated in all the specimens, but the fringe of pile is practically absent in all the examples. The three dark red spots also are not seen on the carapace of any of the specimens.

The tips of the lateral spines of the carapace and the chelipeds and the distal parts of the fingers are brownish in colour.

Chopra mentioned the range of distribution of *C. merguiensis* from Hongkong in the east to the coast of Palestine in the Mediterranean Sea on the west. Sakai has given a record of occurrence of the species from Japan also and has thus extended the range considerably.

[1] Chopra, *Rec. Ind. Mus*, XXXVII, p. 485, text-fig. 8 (1935).

Charybdis (Goniosoma) ? callianassa (Herbst).

1935. *Charybdis (Goniosoma) callianassa,* Chopra, *Rec. Ind. Mus.* XXXVII, pp. 489-491, pl. ix, fig. 1.

A single small female specimen in Prof. Meggitt's first collection from Maungmagan is referred to the present species with some doubt. The specimen is very immature and is badly damaged.

C. callianassa, as mentioned by Chopra, is known to occur from the Gulf of Siam to Karachi.

Thalamita prymna (Herbst).

1899. *Thalamita prymna,* Alcock, *Journ. As. Soc. Bengal* LXVIII, pp. 78, 79.
1922. *Thalamita prymna,* Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 112.

There is one ovigerous female belonging to the present species in Prof. Meggitt's first collection; this was collected at Cat's Eye Rocks, Maungmagan.

The specimen agrees closely with Alcock's description, as also with named specimens in the Museum collection.

The species is represented in the collection of the Indian Museum by several specimens collected in the Bay of Bengal from Mergui to Madras. Balss gives its distribution as : " Natal, Rotes Meer, Indische Küsten und Inseln, Malayischer Archipel, Liu-Kiu-Inseln, Japan (Tokiobai), Australien, Neu-Caledonien, Tongatabu, Samoainseln ".

Family XANTHIDAE.

Subfamily *XANTHINAE.*

Carpilodes margaritatus A. M.-Edw.

1898. *Carpilodes margaritatus,* Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 85, 86.
1925. *Carpilodes margaritatus,* Odhner, *Handl. Kungl. Vetensk. Vitterh. Göteborg* XXIX, No. 1, pp. 24, 25, pl. ii, fig. 4.

A single specimen from Drs. Prashad and Chopra's collection from Mergui is referred to the present species.

C2287/1	A submerged coral reef, off Jounjounja, a small rocky Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 20th Jan. 1937.	1 ♂

The specimen has the following measurements (in millimetres) :—

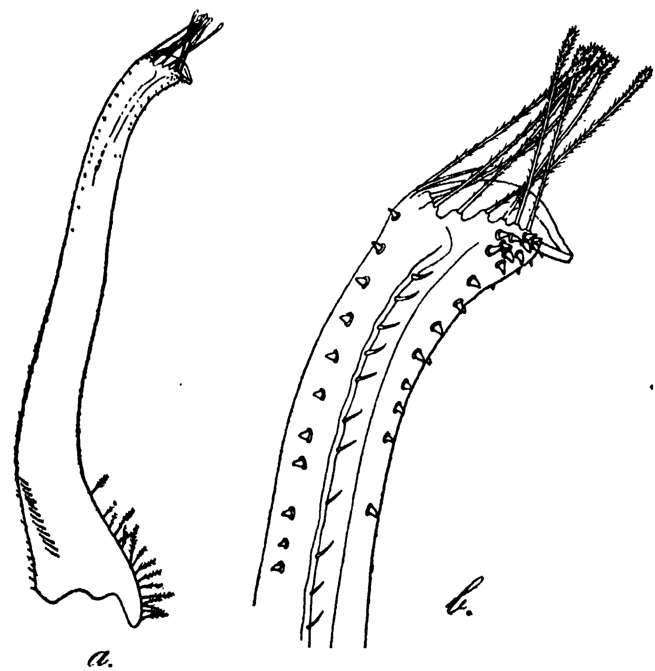
Length of carapace	5·8
Greatest breadth of carapace	9·4
Breadth of front	3·3

The specimen agrees exactly with the figure given by Odhner, as also with the figure and brief description of A. Milne-Edwards.[1] The breadth of the front does not appear to be a constant character of the species. In our example it is slightly more than one-third of the carapace breadth, as is the case in Odhner's figure also. In a specimen of

[1] A. Milne-Edwards, *Nouv. Arch. Mus. Paris* IX, p. 182, pl. v, fig. 2 (1873).

C. dioderus, which according to Odhner is only a synonym of the present species, the front is stated to be sometimes very much narrower.

The anterior male appendages of *C. margaritatus* are illustrated in the accompanying text-figure. Each appendage is practically straight



TEXT-FIG. 5.—*Carpilodes margaritatus*, A. M.-Edw.

a. Anterior left pleopod of male: ×40. *b.* Tip of the same enlarged: ×113.

and has a short claw-like tip. There are some long club-shaped, feathery hairs just below the tip on the exposed surface of the appendage, and some more or less similar, but shorter hairs near the base on the outside. Along both the margins behind the tip there are some very minute spinules, and a number of these bunched together just close to the tip on the outer side. The characteristic "scroll-like projection" shown in the figure given by Miss Gordon[1] for *C. lippus* (Nobili) is not present in this species.

C. margaritatus seems to be rare in Indian waters. There is no example of this species in the collection of the Indian Museum and Alcock included it in the Indian fauna on the authority of Henderson.[2] The species according to Odhner, however, has a wide range of distribution, having been recorded from a number of places from Samoa on the east to Madagascar and the Red Sea on the west.

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[1] Gordon, *Mem. Mus. Roy. Hist. Nat. Belgique* III, Fasc. 15, pp. 24, 25, text fig. 13 (1934).

[2] Henderson, *Trans, Linn, Soc, London* (2) V, p. 353 (1893).

Atergatis integerrimus (Lamarck).

1898. *Atergatis integerrimus*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 95, 96.
1922. *Atergatis integerrimus typicus*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 124.

There is one young female of this somewhat common species in Prof. Meggitt's first collection from Mergui. The carapace breadth of the specimens is about 35 mm.

The present specimen agrees closely with named examples in the Museum collection. The surface of the external maxillipeds has, however, a scanty growth of short hairs, and the walking legs, in addition to the usual little tuft of hairs near the far end of lower border of the propodus, have a few stiff hairs in a similar position on the ischium and merus also. In the allied species *A. dilatatus* de Haan (see Alcock, *op. cit.*, p. 97) the external maxillipeds are closely covered with long thick bristles and the lower border of ischium and merus of the walking legs has remarkable comb-like tufts of long stiff bristles.

A. integerrimus has a wide range of distribution, having been recorded from several localities from Japan to Zanzibar on the east African coast. In the Indian Museum there are examples from the Bay of Bengal only.

Xantho neglectus Balss.

1898. *Xantho distinguendus*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 113, 114 (*nec* 1835. *Xantho distinguendus*, de Haan, *Faun. Japon. Crust.*, p. 48, pl. xiii, fig. 7; 1922. *Xanthodius distinguendus*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, pp. 127, 128).
1922. *Xantho neglectus*, Balss, *Zool. Anz.* LIV, p. 6 (name only).

On account of the fact that de Haan (*op. cit.*, p. 66) described the tips of the fingers in his *Xantho distinguendus* as " obtusis ", Balss is of the opinion that de Haan's species cannot be retained in the genus *Xantho*, and further as in Alcock's (and several other authors') *Xantho distinguendus*, among other characters, the fingers are sharp-pointed, this crab, though rightly placed in the genus *Xantho*, cannot be considered the same form as de Haan had described under the name of *distinguendus*. Balss has, therefore, given the new name *neglectus* to the form that Alcock and several other writers had identified and described as *Xantho distinguendus* of de Haan. We have not gone deeply into this matter, but as the specimens[1] in the Indian Museum collection identified by Alcock as *Xantho distinguendus* differ considerably from the detailed description of *Xanthodius distinguendus* given by Balss in *Archiv für Naturgeschichte* (*loc. cit.*), we have preferred to adopt Balss' name for the Indian form.

There are six specimens of this species, one from Mergui and five from Maungmagan Rocks, low tide, in the two collections of Prof. Meggitt. They are all small and both the sexes are represented. The specimens agree closely with named examples in our collection, as also with Alcock's excellent description of the species.

[1] The specimens from Hongkong differ from all the other specimens in the collection in having the tips of their figures blunt and hollowed out, in having the carapace and chelipeds more profusely granulated and in a number of other characters. They agree fairly closely with the description of *Xanthodius distinguendus* given by Balss, and are probably referable to this species.

X. neglectus is represented in the Indian Museum collection by several specimens both from the Bay of Bengal and the Arabian Sea. The species seems to have a wide range over the Indo-Pacific area.

Leptodius exaratus (M.-Edwards).

1898. *Xantho (Leptodius) exaratus*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 118, 119.
1922. *Leptodius exaratus*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 127.
1934. *Xantho (=Leptodius) exaratus*, Gordon, *Mem. Mus. Roy. Hist. Nat. Belgique* III, Fasc. 15, pp. 29, 30.

A large number of specimens referable to this common Indo-Pacific species are represented in both the collections of Prof. Meggitt as also in that of Drs. Prashad and Chopra from Mergui. Both the sexes are represented and some of the females are ovigerous. The largest male specimen has a carapace length of 14·5 mm. and carapace breadth of 22·5 mm. Some of the very small specimens have the claws and most of the walking legs missing. Three or four specimens are infested with Rhizocephala.

There seems to be a great deal of variation in the shape and acuteness of the lateral lobes and teeth of the carapace; in younger individuals generally, though not always, the lobes are less distinct and the teeth are blunter. The carapace is non-granular in practically all the specimens.

In the Indian Museum there are numerous examples of this species from both the Bay of Bengal and the Arabian Sea, including the Persian Gulf. The species has a very wide range of distribution over the Indo-Pacific area having been recorded from a larger number of localities from Polynesia to the east coast of Africa.

Leptodius cavipes (Dana).

1898. *Xantho (Leptodius) cavipes*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 122, 123.
1906. *Leptodius cavipes*, Nobili, *Ann. Sci. Nat. Paris* (9) IV, p. 243.

Two male examples of this somewhat rare species were collected by Prof. Meggitt from under stones in rock pools, between tide-marks at Maungmagan in October, 1933, along with a large number of specimens of the preceding species.

The species is easily recognised, among other characters, by the presence of a trough-like concavity on the upper surface of the carpopodites of the walking legs. Both our specimens agree in every respect with named specimens in the Museum collection.

L. cavipes is represented in the collection of the Indian Museum by specimens from Mergui, Andaman Islands and the Palk Strait between India and Ceylon. The species has a wide range of distribution, having been recorded from Bonin Island in the North Pacific in the east to the Red Sea and the east African coast on the west. Sakai[1] has recorded it from the Japanese coast.

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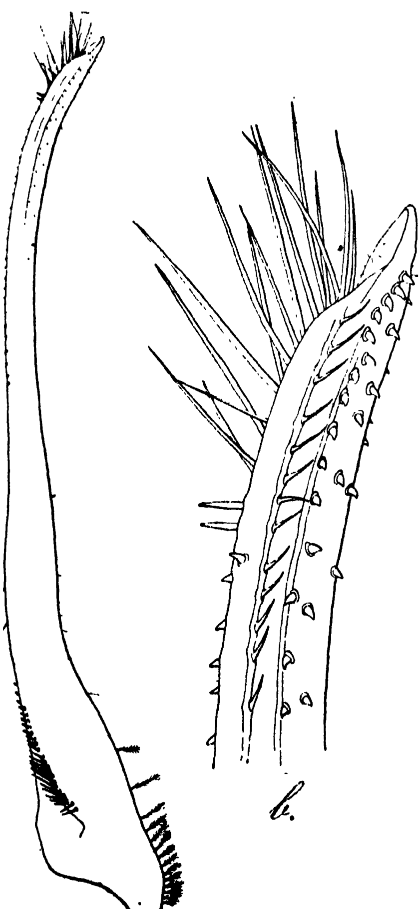
[1] Sakai, *Sci. Rep. Tokyo Bunrika Daigaku* (B) I, No. 25, p. 310 (1934).

Subfamily *ACTAEINAE.*

Actaea areolata Dana.

1898. *Actaea areolata,* Alcock, *Journ. As. Soc. Bengal* LXVII, p. 141.
1925. *Actaea areolata,* Odhner, *Handl. Kungl. Vetensk. Vitterh. Göteborg* **XXIX,** No. 1, pp. 65, 66, pl. iv, fig. 12.

On account of the fact that Alcock described a dense covering of fur on the carapace of the single specimen from Mergui that he had examined, Odhner has expressed the opinion that Alcock's (and de Man's[1]) *A. areolata* is not the same form as that described by Dana[2] under this name. Unfortunately this specimen from Mergui cannot be



TEXT-FIG. 6.—*Actaea areolata* Dana.
a. Left anterior pleopod of male : ×28. *b.* Tip of the same enlarged : ×113.

traced in the Museum collection and we are, therefore, unable to compare it with Odhner's description of the species. There are, however,

[1] de Man, *Journ. Linn. Soc. London* (*Zool.*) XXII, pp. 25, 26 (1887).
[2] Dana, *U. S. Explor. Exped. Crust.* I, pp. 162, 163, pl. viii, figs. 1*a*, *b* (1852).

three examples from Mergui in the present collection that are clearly referable to Dana's *A. areolata*. Two of these are males (the larger one having a carapace length of 9·5 mm. and carapace breadth of 12·5 mm.) and the third, a young female. These specimens agree almost exactly with the descriptions and figures of Dana and Odhner. The hairs on the carapace are short and do not conceal the granulation and much less the areolae. The arrangement of the granules and the hairs is exactly as described and figured by Dana. The basal antennal joint reaches little beyond the front and the orbital border, therefore, does not form a complete ring as is shown by Odhner (*op. cit.*, pl. iv, fig. 11*a*) in his figure of *A. semoni* (Ortmann). The areolae of the carapace are almost exactly as in Odhner's figure of *A. areolata*, the only difference from Dana's figure being in the fact that the innermost areola on the protogastric lobe (2 M) is hardly broader than the areola on the mesogastric lobe (3 M). This difference was noticed by de Man in the case of his specimen from Mergui also. The mesogastric areola is in the form of an inverted T. The claws are densely hairy as described by Alcock.

We give here a figure of the anterior abdominal appendage of one of our male specimens. These are long and slender and are more or less of the type usual in the genus *Actaea*. The tips are as shown in the figure.

In the absence of the specimen on which de Man and Alcock based their descriptions of *A. areolata* it is difficult to express any opinion on Odhner's observations, referred to above, regarding the correct identification of this specimen. Our specimens are from more or less the same locality as de Man's and agree with it in practically every character, including the comparatively narrow innermost branch of the areola 2 M. de Man made no mention of the dense growth of hair on the carapace concealing the granulation, though Alcock seems to have considered this point of special importance. Except for a denser growth of hair on the carapace there does not seem to be any other difference between de Man's Mergui specimen and typical examples of *A. areolata* and it seems to us likely, therefore, that this specimen is referable to Dana's species.

The three specimens in the present collection are registered as under :—

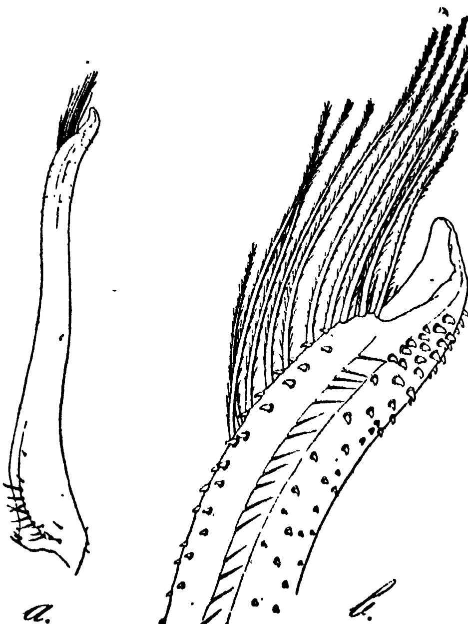
C2288/1	A submerged coral reef, off Jounjounja, a small rocky island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 20th Jan., 1937.	1 ♂
C2289/1	A submerged coral reef near shore, off Palaiow on the east coast of Doung Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 20th Jan., 1937.	1♂, 1 ♀

The only record of *A. areolata* from Indian waters is from the Mergui Archipelago. Odhner has given several records of the species from the east coast of Queensland, Japan, N. W. Australia, Gulf of Siam and Singapore. The species seem to be restricted to the eastern part of the Indo-Pacific area only.

Actaea calculosa (M.-Edwards).

1898. *Actaea calculosa*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 152, 153.
1922. *Actaea calculosa*, Balss., *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 122.
1925. *Actaea calculosa*, Odhner, *Handl. Kungl. Vetensk. Vitterh. Göteborg* XXIX, pp. 52, 53.

The present species resembles very closely *Actaea granulata* (Audoin), which according to Odhner and some other writers should be known



TEXT-FIG. 7.—*Actaea calculosa* (Milne-Edwards).

a. Left anterior pleopod of male : × 20. *b.* Tip of the same enlarged : × 83.

under H. Milne-Edwards' name of *savignyi*. The differences between *A. calculosa* and *A. savignyi* have been fully described by Alcock and Odhner. The male appendages also show some differences.

A. calculosa is represented in our collection by one male specimen (carapace length 7·7 mm., carapace breadth 10·5 mm.), collected by Drs. Prashad and Chopra from amongst corals in a submerged reef near shore, off Palaiow on the east shore of Doung Island in the Mergui Archipelago on 20th Jan., 1937. It agrees very closely with named examples of this species in the Museum collection.

The anterior male appendages are as shown in the accompanying text-figure. They are shorter and stouter than those of the preceding species, and the tip is blunter and somewhat more upturned. The hairs on the inner margin just behind the tip are also longer and have minute secondary hairs on them.

A. calculosa is represented in the Indian Museum collection by specimens from Mergui, Karachi and the Persian Gulf. Balss gives the distribution of the species from Torres Strait and Japan to the Red Sea. Odhner has extended the known range considerably by giving records of occurrence of the species from Adelaide, South Australia, and Tahiti in the Pacific.

Subfamily CHLORODINAE.

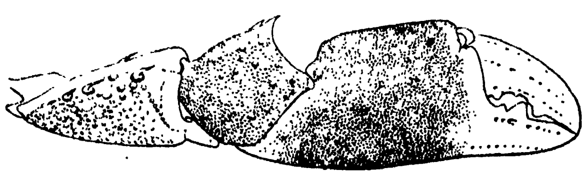
Chlorodiella niger (Forskål).

(Plate VI, fig. 2.)

1898. *Chlorodius niger*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 160, 161.
1936. *Chlorodiella niger*, Sakai, *Sci. Rep. Tokyo Bunrika Daigaku* (B) II, p. 166.

This common Indo-Pacific species was collected from a number of localities in the Mergui Archipelago by Drs. Prashad and Chopra and is represented in our collection by several specimens. Most of the specimens are small, the largest male having a carapace length of 7·8 mm. and carapace breadth of 11·5 mm. The species does not grow to a large size, as some of the females with a carapace length of between seven and eight millimetres are ovigerous.

An examination of some of the very young examples in our collection has shown that in a number of characters young individuals show considerable difference from adults. In one female specimen (plate VI, fig. 2) with a carapace length of about 4 mm. the external orbital tooth is sharper than is usually the case, the first spine on the antero-lateral border is very small, blunt and almost like a tubercle, the next two spines are sharp and prominent and the fourth is smaller and blunter than the two preceding ones. There are a few stiff hairs scattered on the carapace, especially in the anterior part and along the edge of the front. The cheliped also shows some differences. There is a sharp spine on the anterior border of the arm, and the posterior border also has a spine and some crenulations. The inner angle of the wrist has



TEXT-FIG. 8.—*Chlorodiella niger* (Forskål).
Right chiliped of a small female specimen, with a carapace length of about 4 mm., outer and upper view: × 13.

two sharp and unequal spines. Further in the walking legs the anterior border of the merus is crenulate, or even sometimes spiny.

Some very young examples from the named collection of the Indian Museum that we have examined show all these characters clearly. In specimens even a little over 5 mm. in carapace length these characters can be seen. In slightly larger examples the fourth spine of the lateral margin of the carapace becomes increasingly acute; the second spine on the wrist becomes smaller and the other becomes a little blunter. In examples with a carapace length of 6 mm. all the characters of the adult can generally be seen.

Chlorodiella niger is represented in the Museum collection by a large number of specimens mostly from the Bay of Bengal. The species has a wide range of distribution, being known to occur from Hawaii on the east to the Red Sea and the African coast on the west. Sakai has given the records of its occurrence from Japan.

Cymo melanodactylus de Haan.

1898. *Cymo melanodactylus*, Alcock, *Journ. As. Soc. Bengal* LXVII, p. 174.

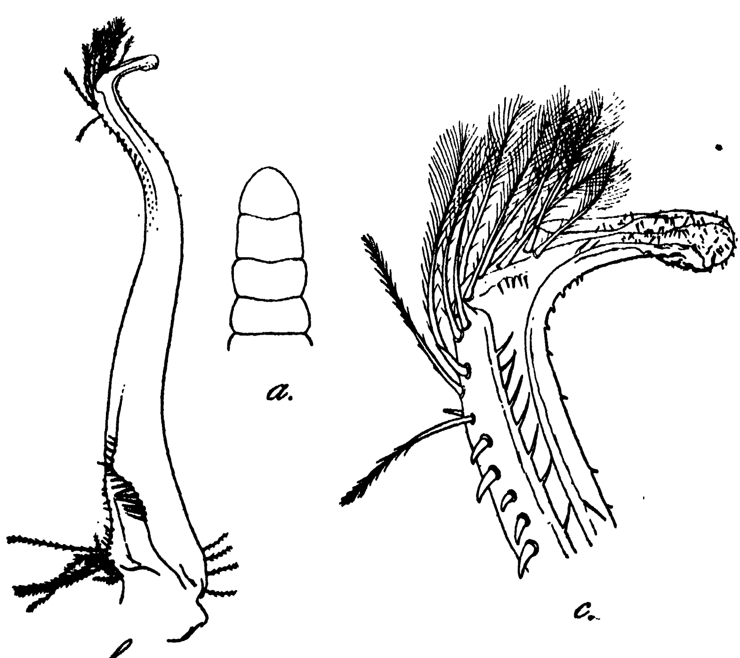
There are two male examples of the present species from Drs. Prashad and Chopra's collection from Mergui.

C2290/1	Submerged coral reef, off Cantor Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 19th Jan., 1937.	1 ♂
C2291/1	Submerged coral reef near shore, off Palaiow on the east coast of Doung Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 20th Jan., 1937.	1 ♂

The specimens have the following measurements, in millimetres :—

Length of carapace	10·0	7·2
Greatest breadth of carapace	11·0	8·0
Breadth of front	4·7	3·5

C. menlanodactylus seems to be variable in the amount of granulation and lumps on the carapace, some specimens in the Museum collection having the carapace even more or less smooth. Similarly the tubercles on the chelipeds show considerable variation. In our examples the rows



TEXT-FIG. 9.—*Cymo melanodactylus* de Haan.

a. Terminal part of male abdomen of one of our specimens : × 4½. *b.* Left anterior male pleopod : × 23. *c.* Tip of the same enlarged : × 93.

of tubercles on the upper surface and also on the outer surface near the upper border of the hand are in the form of broad-based, curved spines.

Some of the tubercles on the outer surface of the hand, unlike what is mentioned by Stimpson[1], are also reddish in colour. The basal parts of the fingers are strongly granulated, and are black. The dactyli of the walking legs are also tipped black.

The penultimate segment of the male abdomen in both our specimens has practically straight sides, whereas in some of the named examples in the Museum collection the sides are distinctly concave. The last segment also appears to be somewhat longer.

The anterior abdominal appendages of the male are sharply bent upwards (as seen in a specimen lying on its back) near the tip. Their form is shown in the accompanying text-figure. The tips are bluntly pointed and are beset with numerous minute spines. On the inner side just behind the tip there is a bunch of long plumose hairs, and the outer border behind the tip is a little serrate. In specimens in the Museum collection with sixth segment of the male abdomen having concave sides the anterior abdominal appendage does not show any material differences from what has been described above.

In the Indian Museum there are specimens of *C. melanodactylus* from Mergui, Andamans and Ceylon. According to Balss[2] the species is known from Tahiti to east coast of Africa.

Subfamily *MENIPPINAE.*

Menippe rumphii (Fabricius).

1898. *Menippe rumphii*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 178, 179.
1936. *Menippe rumphii*, Shen, *Chinese Journ. Zool.* II, p. 67.

There are several specimens of this species from Maungmagan in both the collections of Prof. Meggitt. Some of the specimens are light orange in colour on the upper side of the carapace, chelipeds and legs, with the lower side dirty whitish yellow.

The species is very common in Indian waters both in the Bay of Bengal and the Arabian Sea. Its range of distribution in the Indo-Pacific area is very wide.

Myomenippe hardwickii (Gray).

1898. *Menippe (Myomennipe) granulosa*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 179, 180.
1899. *Myomenippe hardwickii*, de Man, *Notes Leyden Mus.* XXI, p. 56.
1934. *Myomenippe hardwickii*, Balss, *Faune des Colonies Francaises* V, Fasc. 8, pp. 516, 517.

The correct synonymy of this species has been given by de Man and Balss.

Two specimens of *M. hardwickii* are in our collection.

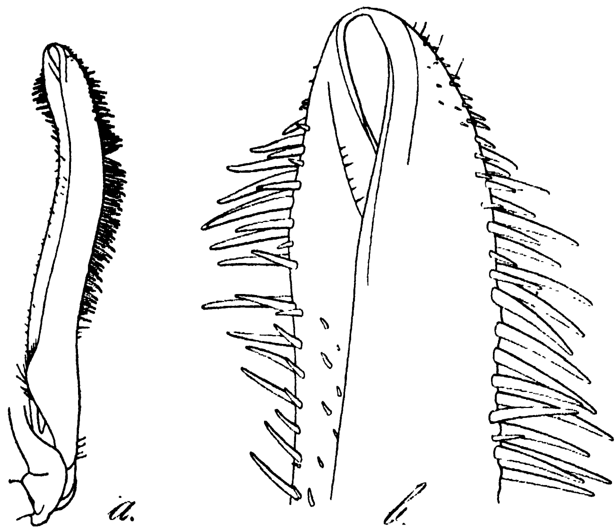
C2292/1	Submerged coral reef, off Cantor Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 19th Jan., 1937.	2 ♂♂

The specimens agree very closely with de Man's[3] detailed description of the species given under the name of *Myomennipe granulosa*, as also

[1] Stimpson (Rathbun), *Smithsonian Misc. Coll.* XLIX, p. 59 (1907).
[2] Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 128 (1922).
[3] de Man, *Journ. Linn. Soc. London (Zool.)* XXII, pp. 40-43, pl. ii, fig. 1 (1887).

with examples named by him and by Alcock preserved in the Museum collection.

The anterior male appendages are as shown in the text-figure; they are short and stout and are rounded at the tip. The usual ciliated



TEXT-FIG. 10.—*Myomenippe hardwickii* (Gray).
a. First left pleopod of male : × 4. *b.* Tip of the same enlarged : × 20.

channel is entirely closed leaving only an ovalish aperture near the distal end. The sides are beset with long stout hairs. The second pleopods are whip-like, as is usual in the subfamily.

The measurements, in millimetres, of the two examples from Mergui are given below :—

Length of carapace	40·0	23·0
Breadth of carapace	55·0	33·0
Distance between external orbital angles ..	27·5	18·0
Length of larger hand and fixed finger along lower border	40·0	23·0

In the Museum collection there are specimens of the present species from several localities in the Bay of Bengal. The only record outside the Bay is that of Balss from Dar-es-Salaam on the east coast of Africa.

Subfamily *OZIINAE*.

Epixanthus frontalis (Milne-Edwards).

1898. *Epixanthus frontalis*, Alcock, *Journ. As. Soc. Bengal* LXVII, p. 185.
1922. *Epixanthus frontalis*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, pp. 132, 133.

Two male examples referable to the present species are in the collection of Drs. Prashad and Chopra from Mergui. They are typical in every respect. The suture below the outer orbital angle is somewhat indistinct.

In the Museum collection there are specimens both from the Bay of Bengal and the Arabian Sea. The species is known from Tasmania to the east coast of Africa and the Red Sea.

Subfamily *PILUMNINAE.*

Pilumnus longicornis Hilgendorf.

(Plate VI, fig. 3.)

1898. *Pilumnus longicornis*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 193, 194.
1898. *Pilumnus andersoni*, Alcock, *op. cit.*, p. 194.
1933. *Pilumnus longicornis*, Balss, *Capita Zool.* IV, Afl. 3, pp. 15, 16.

One specimen of this species, collected by Drs. Prashad and Chopra at Mergui, is in the present collection. We give below its measurements in millimetres.

Length of carapace	10·5
Breadth of carapace	14·0
Breadth of front (distance between internal orbital angles)	4·6
Length of larger hand along lower border	9·2
Height of larger hand	5·0
Length of smaller hand along lower border	8·0
Height of smaller hand	3·5

The specimen has some features which might be mentioned here :—

1. The inner orbital angles are acute.
2. The external margin of the second tooth on the lateral margin of the carapace is distinctly spiniform, that of the third is obscurely so.
3. The subhepatic granule is sharp.
4. The postero-lateral margins of the carapace are slightly more arched than is usually the case.
5. There are two spines on the inner angle of the wrist.
6. Meropodites of the walking legs are spiny on the upper margin.

Most of these characters are seen in our named examples also, though Alcock and some other authors have not mentioned these. The only noteworthy difference between our example and the older specimens that we have examined is in the sharpness of the subhepatic granule and in the postero-lateral margin of the carapace being somewhat more arched. So far as the latter character is concerned it seems, however, that in the males the postero-lateral borders of the carapace are generally arched a little more than in females of the same size.

P. longicornis is represented in the collection of the Indian Museum by specimens from both the coasts, as also from more eastern parts of the Bay. Balss gives the range of the species as: "von Ostafrika bis Hawai und Ponape."

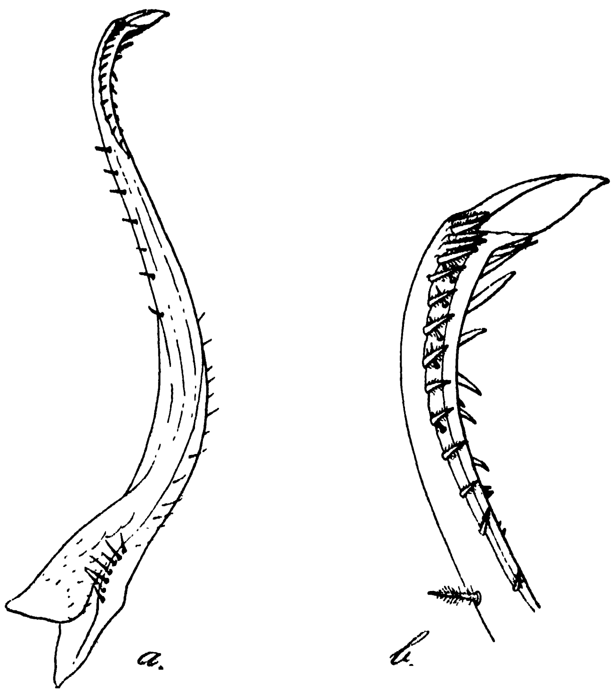
Pilumnus hirsutus Stimpson.

1898. *Pilumnus hirsutus*, Alcock, *Journ. As. Soc. Bengal* LXVII, p. 197.
1922. *Pilimnus hirsutus*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, pp. 117, 118.
1933. *Pilumnus hirsutus*, Balss, *Capita Zool.* IV, Afl. 3, p. 20.

There are three examples of *P. hirsutus* in the present collection. They were collected by Drs. Prashad and Chopra in different localities in the Mergui Archipelago; two of these are young males and the third, a young female. The specimens are typical.

The amount of granulation on the large claw varies considerably in our named examples.

The anterior abdominal appendages of the male from Mergui are as shown in the accompanying text-figure. In their general appearance



TEXT-FIG. 11.—*Pilumnus hirsutus* Stimpson.
a. Left anterior pleopod of male: × 34. *b.* Tip of the same enlarged: × 113.

they more or less conform to the type figured by Balss (1933, *op. cit.*, p. 10, fig. 2) as characteristic of the subfamily Pilumninae, but they seem to show a closer resemblance to the appendages figured by Miss Gordon[1] as of *P. seminudus* Miers, which species Balss (1933, *op. cit.*, pp. 13 and 39) has transferred to his new genus *Glabropilumnus*.

In the Museum collection there are specimens of the present species from the eastern part of the Bay of Bengal only. Balss (1922, *loc. cit.*) gives the range of distribution of the species as New Caledonia to the Red Sea, extending as far north as Korea on the coast of China.

[1] Gordon, *Journ. Linn. Soc. London* (Zool.) XXXVII, p. 541, text-fig. 17*a*, *b* (1931).

Actumnus elegans de Man.

1898. *Actumnus elegans*, Alcock, *Journ. As. Soc. Bengal* LXVII, p. 206.
1933. *Globopilumnus globosus*, Balss, *Capita Zool.* IV, Afl. 3, p. 7, pl. i, figs. 1 and 2 (*partim*).

Balss is of the opinion that the form described by de Man and Alcock as *Actumnus elegans* is only a young stage of Dana's[1] *Pilumnus globosus*, which species he has transferred to his new genus *Globopilumnus* in the subfamily Menippinae. He was led to this opinion on a comparison of de Man's paratype of *A. elegans* with young specimens of, what he identified as, *Pilumnus globosus* of Dana. We are unable to subscribe to this view. We have before us one of the original specimens of de Man from Mergui (labelled co-type), two specimens from Kyuk Phyu Harbour and four examples from Mergui recently collected by Drs. Prashad and Chopra. All these seven specimens agree very closely with the descriptions of de Man and Alcock, and are no doubt conspecific. One of these specimens, from Kyuk Phyu, is an ovigerous female and, shows unmistakably all the characters on which de Man based his species. This specimen, which is the largest in our collection, has the following measurements (in millimetres) :—

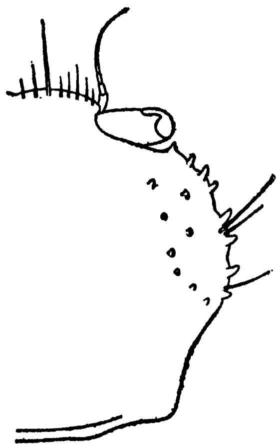
Length of carapace	7·2
Greatest breadth of carapace	9·2
Breadth of front	3·0
Breadth of fronto-orbital border	6·2

It would thus appear that *Actumnus elegans* is normally a small species, and what Balss believed to be the characters of the young only persist up to the adult stage also. The co-type from Mergui is a young male with a carapace length 3·9 mm. and there are hardly any characters to distinguish this specimen from the ovigerous female referred to above.

Actumnus elegans is easily recognised, among other characters, by the paired arrangement of the spinuliform granules on the antero-lateral margins of the carapace. Typically there are eight of these granules on each margin; six of these are arranged in three pairs, the seventh is between the granules of the first pair and the outer orbital angle and the eighth is at the outer orbital angle itself. We give here an outline-figure of the carapace of the ovigerous female from Kyuk Phyu and the disposition of the granules will be clearly seen from it. In one of the recently collected specimens from Mergui, however, there are two or three additional minute granules in between the larger paired granules. In all the other examples the number and arrangement of the granules is quite typical. In Dana's *Pilumnus globosus*, as described both by Dana and de Man,[2] there are only three or four isolated granules on the antero-lateral border of the carapace. The upper orbital border in *Actumnus elegans*, as described by de Man[3] has a characteristic shape. In de Man's words " the frontal or inner part of the upper margin of the orbits makes nearly right angles both with the frontal and the external, somewhat granular portion of the upper orbital margin " ; this is

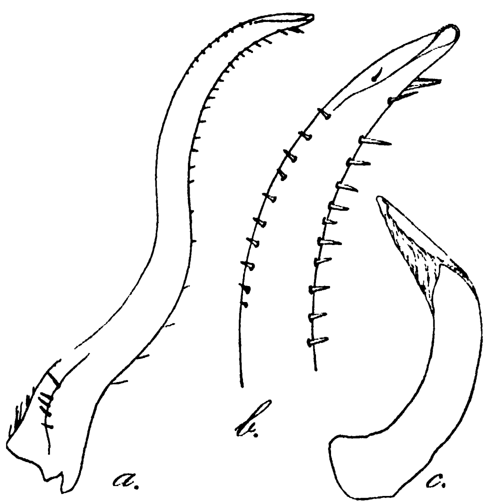
[1] Dana, *U. S. Explor. Exped. Crust* I, pp. 236-237, pl. xiii, fig. 10 (1852).
[2] de Man, *Notes Leyden Mus.* XII, pp. 59-61, pl. xiii, fig. 10 (1890).
[3] de Man, *Journ. Linn. Soc. London* (Zool.) XXII, pp. 47-49 (1887).

clearly seen in the text-figure. In *P. globosus*, as seen in Dana's figure, the upper margin of the orbit. is regularly rounded.



TEXT-FIG. 12.—*Actumnus elegans* de Man.
Upper view of carapace of ovigerous female specimen from Kyuk Phyu : × *ca.* 9.

The abdominal appendages of the male, that we have been able to examine in the single male specimen (co-type from Mergui) in our collection are unmistakbly of the *Pilumnus* type.[1] They are as illustrated



TEXT-FIG. 13.—*Actumnus elegans* de Man.
a. First left pleopod of male : × 41. *b.* Tip of the same enlarged : × 107. *c.* Second left pleopod of male : × 107.

in the accompanying text-figure. The second pleopod is very much shorter than the first and is not whip-like. The species, therefore, cannot be included in the subfamily Menippinae as proposed by Balss.

[1] We have also examined these appendages in a specimen of *A. setifer* (de Haan) that has been seen by Dr. Balss ; they are more or less like those of *A. elegans* in their general form and structure.

The species is represented in the present collection by four examples collected by Drs. Prashad and Chopra in the Mergui Archipelago.

C2293/1	Submerged coral reef off Cantor Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 19th January, 1937.	1♀ from an oyster.
C2294/1	Submerged coral reef off Palaiow on the east coast of Doung Island, Mergui Archipelago.	Drs. B. Prashad and B. N. Chopra, 20th January, 1937.	3 ♀♀ from corals.

One of the specimens from Palaiow is infested with a Rhizocephalon. *A. elegans* is so far known from Mergui only.

Subfamily *ERIPHINAE*.

Trapezia cymodoce (Herbst).

1898. *Trapezia cymodoce*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 219, 220.
1922. *Trapezia cymodoce*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 134.
1936. *Trapezia, cymodoce*, Sakai. *Sci. Rep. Tokyo Bunrika Daigaku* (B) II, pp. 169, 170.

This common coral crab is represented in the collection of Drs. Prashad and Chopra by 19 specimens from a number of localities in the Mergui Archipelago. There are examples of both the sexes and some of the females are ovigerous. The largest specimen, a female, has a carapace length of 15 mm., carapace breadth 19 mm. and the fronto-orbital border 16 mm. One female has two Bopyrids under the carapace, forming lumps one on each side near the junction of the antero-and postero-lateral borders; this specimen has a little pubescence on the carapace, especially in the anterior half. All the specimens are typical.

The species is represented in the collection of the Indian Museum by specimens both from the Bay of Bengal and the Arabian Sea. According to Balss it is distributed from Polynesia to the east coast of Africa.

Trapezia ferruginea, var. **areolata** Dana.

1898. *Trapezia ferruginea*, var. *areolata*, Alcock, *Journ. As. Soc. Bengal* LXVII, p. 221.
1907. *Trapezia cymodoce areolata*, Rathbun, *Mem. Mus. Comp. Zool. Harvard* XXXV, p. 59.

Miss Rathbun is of the opinion that a large number of forms that have been described as *T. cymodoce*, *T. ferruginea* and its varieties or as *T. maculata* are all referable to the first-named species.

We have before us six female examples (three ovigerous) that are referable to Dana's *Trapezia areolata*. These were collected by Drs. Prashad and Chopra in the Mergui Archipelago.

The "elegant honeycomb network of fine brown" described by Alcock is very distinct and in most cases extends to the claws, sides and ventral surface of the carapace and even to the abdomen. The upper part of the outer surface of the hand is finely pubescent in most of the examples.

The largest female has a carapace length of 9 mm., carapace breadth 11·5 mm. and fronto-orbital border 10 mm. The range of distribution of the present form is more or less the same as that of *Trapezia cymodoce*,

Tetralia glaberrima (Herbst).

1898. *Tetralia glaberrima*, Alcock, *Journ. As. Soc. Bengal* LXVII, pp. 223—225.
1922. *Tetralia glaberrima*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft. 11, p. 134,

Like the two preceding species *Tetralia glaberrima* is also very commonly met with living in corals; twelve examples of this species were collected by Drs. Prashad and Chopra from amongst corals in the Mergui Archipelago. Both the sexes are represented in the collection and some of the females are ovigerous. We give below some measurements, in millimetres, of two males and two ovigerous female specimens.

	Ovig. ♀	Ovig. ♀	♂	♂
Length of carapace	10·2	7·5	8·0	8·8
Breadth of carapace	12·2	9·0	9·2	10·0
Breadth of fronto-orbital border...	10·5	8·2	8·2	9·0

In the Indian Museum there are numerous examples of this species both from the Bay of Bengal and the Arabian Sea. The species has a very wide range of distribution over the Indo-Pacific area, being met with from Polynesia to the east coast of Africa.

Family GONOPLACIDAE.

Subfamily *PSEUDORHOMBILINAE.*

Litocheira angustifrons Alcock.

(Plate VI, fig. 4.)

1900. *Litochira angustifrons*, Alcock, *Journ. As. Soc. Bengal* LXIX, p. 315.
1918. *Litocheira angustifrons*, Tesch, *Siboga Exped. Rep.* XXXIX c[1], p. 163, foot-note.
1933. *Heteropilumnus angustifrons*, Balss, *Capita Zool.* IV, Afl. 3, pp. 41-44.

A single specimen of this apparently rare species is in the present collection :—

C2295/1	Palaiow, on the east coast of Doung Island, Mergui Archipelago, on beach at low tide.	Drs. B. Prashad and B. N. Chopra, 20th January, 1937.	1♀

The specimen agrees very closely with Alcock's named examples in the collections of the Indian Museum, as also with his description. Alcock's description of the species is very brief and does not mention several important characters and as Tesch has expressed some doubts about the validity of the species we have thought it desirable to redescribe it in some detail.

The entire surface of the carapace (Plate VI, fig. 4), chelipeds (excepting the fingers) and the legs is covered with a short, dense fur and long silky hairs, the latter being most abundant on the lateral margins of the carapace and on the chelipeds and legs. There is a row of similar hairs

just behind the fronto-orbital margin surmounting a low and somewhat indistinct ridge. The length of the carapace is almost three-fourths of its breadth. It is more or less flat, especially in the posterior part, the anterior region being somewhat curved and markedly deflexed anteriorly. When denuded the surface of the carapace is smooth, with only a few small granules on and near the antero-lateral margins. The regions are very faintly distinguishable and the crecentic groove between the gastric and cardiac regions is deeply impressed.

The fronto-orbital border is distinctly shorter than the length of the carapace, and, as mentioned by Alcock, is about five-ninths of its greatest breadth. The front is strongly deflexed anteriorly and is distinctly bilobed, each lobe being somewhat convex anteriorly. It is a little less than one-third of the carapace breadth. The two lobes of the front are separated from one another by a small deep notch, followed by a shallow groove running longitudinally for some distance on the carapace. The front is not demarcated from the supra-orbital angles.

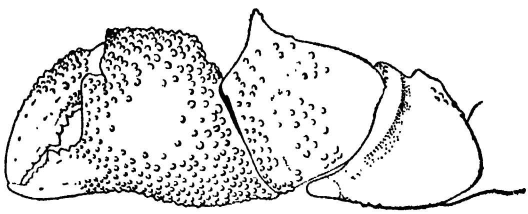
The antero-lateral borders of the carapace are shorter than the postero-lateral and are arched. On each side the antero-lateral margin is cut up by three deep notches into four lobes. The first lobe is confluent with the external orbital angle; its margin is truncate, with the anterior angle acute, and the posterior somewhat blunt. The second lobe is as large as, or even a little larger than the first; its margin is rounded, the anterior angle sharp and the posterior regularly rounded. The third lobe is considerably smaller than the first two and is sharply truncate, while the fourth is the smallest, is triangular and somewhat acutely pointed. The margins of all the lobes are crenulate as is also a small part of the postero-lateral margin of the carapace behind the fourth tooth. The postero-lateral margins are more or less straight and converge posteriorly. The posterior margin is slightly sinuous.

The upper border of the orbit is crenulate. There is a small triangular groove near the outer orbital angle and one in a similar position on the lower border. There is another small and indistinct notch on the middle of the upper border. The outer orbital angle is acute. The eye-stalks are cylindrical, fill up the orbits completely and the greatly reduced and pigmented corneas are somewhat ventrally placed at their tips.

The antennules fold transversely in their fossae and the antennal flagella, as usual, stand in the orbital hiatus. The epistome is quite distinct, and the buccal cavern is somewhat widened anteriorly. The external maxillipeds completely close the buccal cavern and the broad merus has its antero-external angle slightly produced.

The chelipeds are slightly unequal, especially in the male, in which they are about twice the length of the carapace and are almost as long as the penultimate pair of walking legs. In the female the chelipeds are less than twice the carapace length and are shorter than the legs. They are thickly covered with fur and long hairs, except on the fingers which are quite bare. In the Mergui specimen the larger claw has a part of the outer surface of the palm near the distal end also bare, but

in the smaller claw the whole of the outer surface of the palm is thickly covered with hairs. The inner surface of the palm is almost completely devoid of hairs. The upper border of the arm has a thin longitudinal crest on it, with a spine-like lobule near its distal end. There is also an indistinct transverse ridge on the outer face of the arm, a little from the distal end. The wrist has its inner angle acute, almost spiniform, and its upper surface granular, especially near its junction with the hand. The upper surface of the palm is densely covered with granules, and the



TEXT-FIG. 14.—*Litocheira angustifrons* Alcock. Outer view of the left cheliped of male from Karachi : ×3.

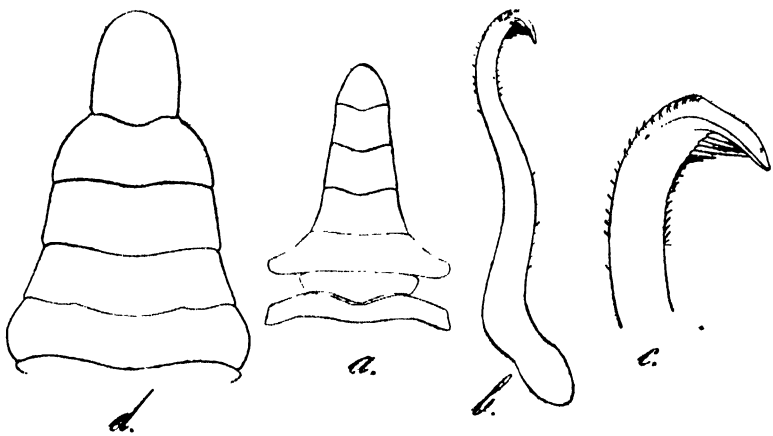
outer surface also is granular, except for a smooth patch in the middle. In the larger chela of the Mergui specimen the outer surface of the palm is quite smooth, as described by Stimpson[1] for *Pilumnoplax ciliata*. The inner surface of the palm is altogether devoid of granules. The upper margin of the palm is straight and is considerably shorter than its height. The fingers are long and stout and the dactylus is slightly arched. The proximal half of the upper surface of the dactylus and less than half of the lower surface of the fixed finger is granular. The cutting edges of the fingers are finely dentate, with one large tooth on each finger about the middle of the cutting edge. There is a small gap near the base when the fingers meet and the pointed tips cross one another slightly.

The third walking legs are the longest, while those of the last pair are the shortest. The merus in all the legs is without any crest, anterior or posterior. The dactyli of the first three pairs are long and straight with short, pointed horny tips, while those of the last pair are short and stout. In the large male specimen from Karachi the third leg of one side is shorter than the second, but it has possibly been regenerated, for it is shorter than the corresponding leg of the other side.

All the seven abdominal segments are distinct in both the sexes. The first segment of the male abdomen (text-figure 15 *a*) occupies all the space between the bases of the last pair of walking legs. The second is narrower, and the third at the base is almost as broad as the first. The sides of this segment converge strongly distally so that it is very much broader at the base than at its distal end. From the third segment the abdomen tapers gradually to the tip. The fourth, fifth and sixth segments are subequal in length and the basal breadth of the sixth is about one and a half times of its median length. The anterior abdominal appendages

[1] Stimpson (Rathbun), *Smithsonian Misc. Coll.* XLIX, pp. 92, 93 (1907).

of the male are somewhat like those of *L. subintegra* Lanchester, as figured by Miss Gordon.[1] The appendages of the two sides are not in any close contact distally and the apex of each is bent outwards and considerably upwards, perhaps not quite as sharply as shown in Miss Gordon's figure. Just behind the tip on the outside there is a tuft of long hairs decreasing in size distally and on the inner side there are a few minute spinules just at the place where the tip bends.



TEXT-FIG. 15.—*Litocheira angustifrons* Alcock. *a.* Abdomen of male specimen from Karachi: ×2⅖. *b.* Anterior left abdominal appendage of same: ×7. *c.* Tip of the abdominal appendage magnified: ×20. *d.* Abdomen of male of *Clistocoeloma balansae*[2] A. M.-Edw.: ×4½.

The older specimens are a dirty light brownish in colour, with the fingers white and the pearly granules on the palm also showing white through the long hairs. In the Mergui specimen the colour is dirty greyish, but on removal of the fur and hairs it is seen to be ivory white. The fingers in this specimen are light brownish in their entire length.

Alcock based the species on two specimens, a female from Bombay and a larger male from Karachi. In the Indian Museum collection the female specimen from Bombay is labelled as the type, and is numbered 6182/3. The species has since been recorded, without any comments, by Borradaile[3] from Male Atoll in the Maldives and has now been obtained from the Mergui Archipelago.

We give below measurements in millimetres and the proportions of certain measurements of the carapace in the three specimens of *L. angustifrons* in the Museum collection. For purposes of comparison we have also included similar measurements and proportions of *L. cristata* Rathbun,[4] so far as published by the author.

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[1] Gordon, *Journ. Linn. Soc. London (Zool.)* XXXVII, p. 549, text-fig. 25*b* (1931).

[2] The figure of the male abdomen of *Clistocoeloma balansae* has been included in this block through a mistake; it should have formed a part of text-figure 21 on p. 432.

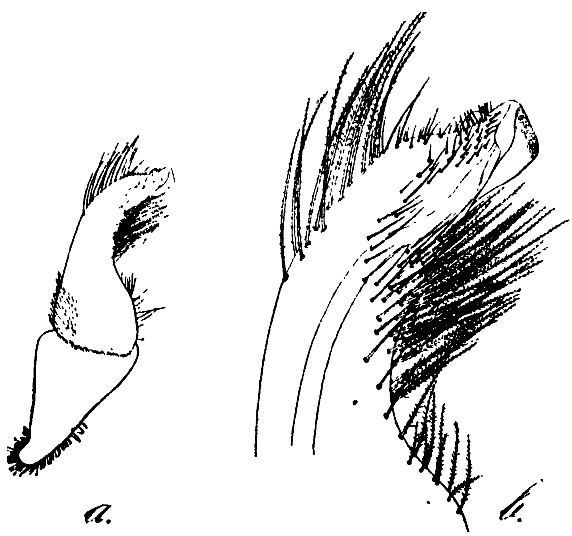
[3] Borradaile, *Fauna Geog. Maldive Laccadive Arch.* I, p. 430 (1903).

[4] Rathbun, *Skrift. K. Dansk. Vidensk. Selsk. Copenhagen* (7) V, pp. 340, 341 (1910).

	L. angustifrons.			*L. cristata.*
	Female Type-specimen from Bombay.	Male from Karachi.	Male from Mergui.	Female Type-specimen.
Length of carapace	11·0	13·2	9·4	5·5
Greatest breadth of carapace	14·8	18·4	12·2	7·7
Fronto-orbital breadth	8·2	10·0	7·0	5·0
Breadth of front	4·6	5·5	4·0	2·8
Length of hand along lower border (large claw)	8·9	13·2	9·0	..
Height of palm (large claw)	5·1	7·8	5·1	..
Length of hand along lower border (small claw)	8·7	12·8	8·4	..
Height of palm (small claw)	4·7	7·4	4·8	..
Penultimate walking leg—				
Length of merus	8·8	9·5	7·5	..
Length of carpus	4·5	11·5	4·2	..
Length of propodus	5·5		4·5	..
Length of dactylus	5·5	6·3	4·7	..
$\frac{\text{Carapace length}}{\text{Carapace breadth}}$	·74	·72	·77	·71
$\frac{\text{Fronto-orbital breadth}}{\text{Carapace breadth}}$	·55	·54	·57	·65
$\frac{\text{Front}}{\text{Carapace breadth}}$	·31	·30	·33	·36

Litocheiria angustifrons resembles *L. ciliata* (Stimpson) and *L. cristata* Rathbun so closely that Tesch has suggested that the three may have to be combined under Stimpson's name. Alcock's species, however, differs from Stimpson's in having a narrower carapace and from both the allied species in having the walking legs without any crest on the merus. In *L. cristata* the upper surface of the wrist is strongly eroded and has a blunt ridge along the inner edge ; there is hardly any trace of the erosion or the ridge in Alcock's species, nor has their presence been mentioned by Stimpson. The front and the fronto-orbital border are also broader in Miss Rathbun's species than in *L. angustifrons*. The walking legs of the second pair are stated to be longer than those of the third in *L. cristata*, while, as is usually the case, the third legs are the longest in both Alcock's and Stimpson's species. The shape of the teeth on the antero-lateral margins of the carapace is also slightly different in Alcock's and Miss Rathbun's species. Stimpson's species is very inadequately known and it is therefore, impossible to enumerate any other differences that may possibly exist between his species on the one hand and Alcock's and Miss Rathbun's species on the other. The general resemblance between the three species is, however, very close and striking.

The position of a number of species grouped in the genus *Litocheira* appears to us to be far from satisfactory. According to Kinhan's[1] definition of the genus and the genotype, in addition to other characters, members of the genus *Litocheira* are characterised by having a front which is about half as broad as the carapace, and by the possession of an orbit the upper border of which is entire. A large number of species that are now included in the genus agree with the type-species, *L. bispinosa*, in these, as also in most other characters, but there are certain others in which the frontal breadth is markedly less than half the carapace breadth, or in which the upper border of the orbit has one or two distinct gaps. In *L. angustifrons*, *L. setosa* (A. M.-Edw.)[2] and *L. integra* (Miers),[3] to mention only the species that we have ourselves examined, the front is either exactly or only a little more than one-third of the carapace breadth, while in *L. angustifrons*, *L. quadrispinosa* Zehntner[2] and perhaps in several others the upper border of the orbit has two more or less distinct gaps. In the matter of the anterior abdominal appendages of the male also there appears to be a great deal of difference between the genotype and several other species. We give here a figure of the anterior male appendage in *L. bispinosa* from a specimen



TEXT-FIG. 16.—*Litocheira bispinosa* Kinhan. *a.* Left anterior pleopod of male : ×12. *b.* Tip of the same magnified : ×35.

from St. Vincent Gulf, South Australia, presented to the Indian Museum, and a comparison of this with the similar appendage of *L. angustifrons* as figured here, or of *L. subintegra* Lanchester, *L. subintegra*, var. *hirsutior* Lanchester and *L. amoyensis* Gordon, as figured by Miss Gordon[4] will

[1] Kinhan, *Journ. Roy. Dublin Soc.* I, pp. 121-123, pl. iii, fig. 1 (1856).

[2] See Tesch, *Siboga Exped. Rep.* XXXIX c[1], pp. 165-167, pl. vii, fig. 1 and pp. 168-171, pl. vii, fig. 3 (1918).

[3] Miers, *Zool. "Alert"*, p. 543, pl. xlviii, fig. c (1884).

[4] Gordon, *Journ. Linn. Soc. London (Zool.)* XXXVII, p. 549, text-fig. 25 (1931).

show the great difference between the appendage of the type-species on one hand, and that of the species named here on the other. We have also examined this appendage in *L. setosa* (A. M.-Edw.) and *L. beaumontii* Alcock[1] and find that in these species also the anterior abdominal appendages of the male are more or less of the same type as in *L. angustifrons* and the other species named here. Miss Gordon[2] believes that in the genus *Litocheira* the anterior abdominal appendages of the male are of two kinds, both the kinds having a beak-like apex, but, differing from one another chiefly in the presence or absence of a very large spine just under the apex; all the species that we have examined, except *L. bispinosa*, or the figures of the male appendages of which have been published conform to one of these types. In the genotype, however, the appendage, besides being short and proportionately very stout, has no beak-like apex. The terminal portion is straight, blunt and truncate and is beset with a profuse growth of long hairs on both the margins. From all the differences enumerated above it seems to us likely, therefore, that the inclusion of some of the species now grouped in the genus *Litocheira* is only a matter of convenience, and does not represent their true natural relationship with the other members of the genus. An examination of the anterior abdominal appendages of the male in all the known species of the genus seems to us very desirable.[3]

Balss has recently suggested that *L. angustifrons* along with some other species that are now included in the genus *Litocheira* should be accommodated in de Man's genus *Heteropilumnus* in the family Xanthidae. From what has been stated above we are also of the opinion that certain species at present assigned to the genus *Litocheira* do not agree with the type-species of this genus in a number of important characters, and it may perhaps be advisable to put such species in another genus. We are not, however, convinced that these species could find a place in the genus *Heteropilumnus* or be included in the family Xanthidae. A considerable amount of further work on all the species included in *Litocheira* and *Heteropilumnus*, and specially on their male appendages, could only settle this point. We have included *L. angustifrons* in the genus *Litocheira* in the family Gonoplacidae chiefly as a matter of convenience.

Family POTAMONIDAE.

Subfamily *POTAMONINAE*.

Potamon (Acanthotelphusa) dayanum (Wood-Mason).

1910. *Potamon (Acanthotelphusa) dayanum*, Alcock, *Cat. Ind. Decapod Crust.* I, *Brachyura* Fasc. II, pp. 61-63, pl. xi, fig. 49.

One large female specimen of the present species is in Prof. Meggitt's first collection from Maungmagan. The exact locality from which it was obtained is not mentioned. The specimen is quite typical. A

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[1] Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 315, 316 (1900).

[2] Gordon, *Journ. Linn. Soc. London (Zool.)* XXXVII, p. 526 (1931).

[3] Of the seven species of the genus *Litocheira* in the Indian Museum collection, *viz.*, *L. bispinosa* Kinhan, *L. setosa* (A. M.-Edw.), *L. beaumontii* Alcock, *L. angustifrons* Alcock, *L. integra* (Miers), *L. quadrispinosa* Zehntner, and *L. kingsleyi* Miers the last three are represented by female examples only.

large number of more or less fully-formed young ones are under the abdomen of the specimen and some are lying loose in the bottle in which it had been put.

There is a large number of specimens of this species in the Museum collection from various localities in Burma. So far as we are aware the species is not known outside the "Burma-Malay Territory" as defined by Alcock (*op. cit.*, p. 10).

Potamon sp.

Two female examples with the chelipeds missing and otherwise badly damaged are in Prof. Meggitt's first collection from Maungmagan. We have found it impossible to give them a specific name.

Subfamily *GECARCINUCINAE*.

Paratelphusa (Phricotelphusa) callianaria (de Man).

1910. *Paratelphusa (Phricotelphusa) callianaria*, Alcock, *Cat. Ind. Decapod Crust.* I, *Brachyura* Fasc. II, pp. 102, 103, pl. xiii, fig. 62.

One female specimen with a carapace length of 10·7 mm. and greatest carapace breadth of 12·5 mm. was collected by Drs. Prashad and Chopra in a small freshwater stream near shore at Kamachaung on the east coast of Doung Island in the Mergui Archipelago. The specimen agrees very closely with the original examples of de Man from Mergui.

The species is represented in the collection of the Indian Museum by specimens from Mergui only. So far as we know it has not been recorded from any other locality.

Family OCYPODIDAE.

Subfamily *OCYPODINAE*.

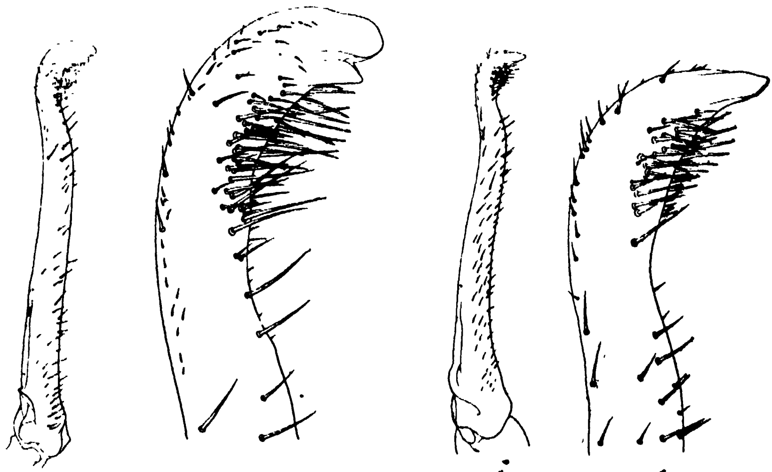
Ocypoda ceratophthalma (Pallas).

1900. *Ocypoda ceratophthalma*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 345-347.
1918. *Ocypoda ceratophthalma*, Tesch, *Siboga Exped. Rep.* XXXIX c, p. 36.
1922. *Ocypoda ceratophthalma*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, pp. 141, 142.
1937. *Ocypoda ceratophthalma*, Tweedie, *Bull. Raffles Mus. Singapore* XIII, p. 141.

A large number of examples of this common Ocypod are in the two collections of Prof. Meggitt from Maungmagan. They were collected on beach and in Rock Pools near shore.

Ocypoda ceratophthalma resembles *O. macrocera* M.-Edwards (*vide infra*) so closely that it is sometimes difficult to distinguish young examples, and especially young females of the two species. The fingers of the smaller chela, however, afford a useful character for separating the species; in *ceratophthalma* these are pointed at the tips, while in *macrocera* the fingers are lamellar right up to the tips, which are broad and blunt and not pointed. The stridulating organ on the inside of the palm is always much shorter and more hairy in the present species than in *O. macrocera*, and, as pointed out by Alcock, consists, in its upper

half, of tubercles gradually passing to striae, which in the lower half are short and generally very closely arranged; in *macrocera* the stridulating ridge consists entirely of striae. The abdomen of the male in the two species is also different; in the present species it is narrower than in *macrocera.* The sixth segment is narrower and longer, its median length being more than its greatest breadth while in *macrocera* the length of this segment more or less equals its greatest breadth. The fifth abdominal segment is also proportionately longer and narrower in the present species than in the allied form. The first pleopods of the male are somewhat



a. *a'.* *b.* *b'.*

TEXT-FIG. 17.—*a.* First left pleopod of male in *Ocypoda ceratophthalma* (Pallas): $\times 5\frac{3}{5}$, *a'.* Tip of the same enlarged: $\times 21$. *b.* First left pleopod of male in *Ocypoda macrocera* Milne-Edwards: $\times 5^3$. *b'.* Tip of the same enlarged: $\times 22$.

different in the two species, as is seen in the accompanying text-figure. In the present species the appendage is a little more sharply bent near the tip, which is more rounded and consists of two somewhat flattened and distally rounded lobes, separated by a narrow incision between them. In *O. macrocera* there is just a suggestion of the incision, but the two lobes are not differentiated.

In young examples the horn at the end of the eye is generally very poorly developed.

O. ceratophthalma occurs very commonly in the Bay of Bengal. Balss gives the distribution of the species as Tahiti to the east coast of Africa.

Ocypoda macrocera Milne-Edwards.

1900. *Ocypoda macrocera,* Alcock, *Journ. As. Soc. Bengal* LXIX, p. 347.
1915. *Ocypoda macrocera,* Kemp, *Mem. Ind. Mus.* V, pp. 219, 220.

A number of examples of this species were collected by Prof. Meggitt in Rock Pools near shore at Maungmagan in October 1933.

The species can be distinguished from the closely similar *O. ceratophthalma* by the characters enumerated above. The characters of the male abdomen appears to be constant even in young examples. The present species is of a smaller size than the preceding one.

Kemp has described the colour of the species and has given very interesting notes on the habits, etc., of the species, in its early stages.

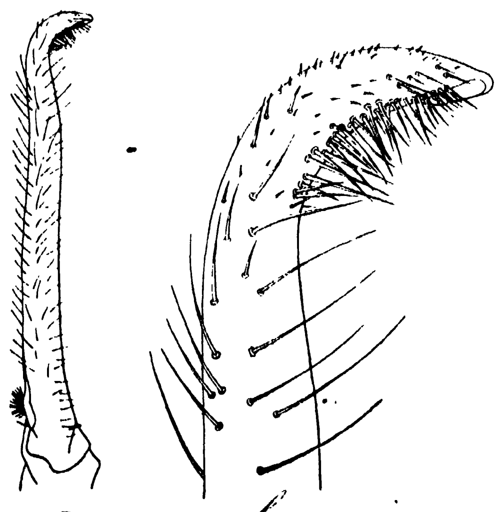
The species is mostly confined to the Bay of Bengal only, though it has been recorded from the Gulf of Siam also.

Ocypoda cordimana Desmarest.

1900. *Ocypoda cordimana*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 349, 350.
1918. *Ocypoda cordimana*, Tesch, *Siboga Exped. Rep.* XXXIX c, pp. 35, 36.
1922. *Ocypoda cordimana*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft. 11, p. 142.

Several large males and females of this species are in Prof. Meggitt's second collection from Maungmagan. The specimens are typical and agree very closely with named examples in our collection, as also with Alcock's description of the species.

The anterior abdominal appendages of the male are more or less like those of *O. macrocera* (*vide* p. 419 and text-figure 17 *b*, *b'*). There is no deep incision separating the two lobes at the tip, though the lobes



a. *b.*

TEXT-FIG. 18.—*Ocypoda cordimana* Desmarest. *a*. First left pleopod of male : ×5. *b*. Tip of the same enlarged : ×20.

are better differentiated than in the other species. The condition is more or less intermediate between *O. ceratophthalma* and *O. macrocera*.

O. cordimana occurs very commonly in the eastern part of the Indo-Pacific area. There is a large number of specimens of the species in the collection of the Indian Museum from various localities in the Bay of Bengal, but none from the Arabian Sea. Balss gives the range of distribution as Tahiti to the Red Sea. The species is frequently met with in Japan also.

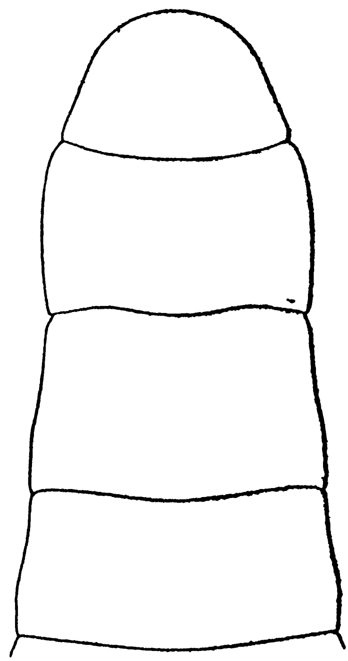
Gelasimus[1] **triangularis** A. Milne-Edwards.

1900. *Gelasimus triangularis*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 356, 357.

1937. *Gelasimus triangularis*, Tweedie, *Bull. Raffles Mus. Singapore* XIII, p. 144, fig. 1c.

A single male specimen of this species was collected by Drs. Prashad and Chopra in Bockachaung, a small freshwaters tream near Mergui. The specimen, which is quite typical, has a carapace length of 6·5 mm., carapace breadth of 11·5 mm. and the large hand is 13·2 mm. long.

The male abdomen in this species is as shown in text-figure 19. The fifth segment is somewhat broader than long, and is appreciably



TEXT-FIG. 19.—*Gelasimus triangularis* A. M.-Edw.

Terminal part of male abdomen : ×17.

longer than the fourth and the sixth segments. The seventh segment is semicircular. The anterior pleopod of the male has been figured by Tweedie.

G. triangularis is a very common species in the Bay of Bengal and is known to extend up to New Caledonia in the east.

[1] We agree with Miss Gordon that the name *Galasimus* should be retained for the Fiddler-crab in preference to *Uca* Leach : see Gordon, *Mem. Mus. Roy. Hist. Nat, Belgique* III, Fasc. 15, p. 10, foot-note (1934).

Gelasimus marionis (Desmarest).

1900. *Gelasimus Marionis* and var. *nitidus*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 359, 360.
1918. *Uca marionis*, Tesch, *Siboga Exped. Rep.* XXXIXc, pp. 38, 39.
1922. *Uca marionis nitidus*, Balss, *Arch. Naturgesch.* LXXXVIII, p. 143.
1937. *Gelasimus marionis* and var. *nitidus*, Tweedie, *Bull. Raffles Mus.* XIII, pp. 143, 144, fig. 1 *d*, *e*.

Tesch has shown that *Gelasimus nitidus* of Dana, or the variety *excisa* Nobili of the species *marionis*, as it should be called, is only a claw-variation of Desmarest's species and as such should not be recognised as distinct from the *forma typica*. This view is further confirmed by Tweedie who failed to find any significant differences between the abdominal appendages of the male in the two forms. According to Tweedie it is probably a case of " geographically local dimorphism confined to the males " ; the females in the two forms are inseparable.

Five large males and a female of this species were collected by Drs. Prashad and Chopra on beach at low tide at Palaiow on the east coast of Doung Island in the Mergui Archipelago. The species is represented in the Museum collection by a large number of examples from the Bay of Bengal and some from the Arabian Sea. Balss gives the range of distribution of the species from Samoa and Fiji Island to the east coast of Africa and the Red Sea.

Gelasimus manii (Rathbun).

1900. *Gelasimus acutus*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 360, 361.
1918. *Uca manii*, Tesch, *Siboga Exped. Rep.* XXXIXc, p. 38.
1937. *Gelasimus manii*, Tweedie, *Bull. Raffles Mus. Singapore* XIII, p. 143, fig. 1 *b*.

Miss Rathbun has shown (see Tesch, *loc. cit.*) that *Gelasimus acutus* of de Man and Alcock is not the same form as *Gelasimus acutus* of Stimpson, which is synonymous with *G. dussumieri* Milne-Edwards. For de Man's form she has given the name of *Uca manii*.

G. manii is represented in our collection by a large number of specimens from Maungmagan and some from Bockachaung, a freshwater stream near Mergui. All the specimens are typical, agreeing very closely with the descriptions of de Man and Alcock, as also with examples named by them.

The front measured between the bases of the eye-stalks is about one-twelfth of the greatest breadth of the carapace, but rarely it is a little narrower than this even. Tweedie has figured an anterior pleopod of the male.

The species is known from both the coasts of India, but is most common in the Bay of Bengal.

Subfamily *SCOPIMERINAE*.

Dotilla intermedia de Man.

1919. *Dotilla intermedia*, Kemp, *Rec. Ind. Mus.* XVI, pp. 331-333.

Three male examples referable to the present species were found mixed with specimens of *Ocypoda macrocera* collected by Prof. Meggitt at Maungmagan. Two of these are mutilated, but the third has most of the legs intact.

The specimens agree closely with the description of *D. clepsydrodactylus* Alcock[1] or with that of "high" males of *intermedia*, as described by Kemp. As Kemp has shown these species are synonymous. We have compared our examples with the named material, including types of the two species, in our collection.

D. intermedia is represented in the collection of the Indian Museum by a large number of specimens from the Mergui and Tavoy coasts of Burma and the Orissa coast of India. To our knowledge the species has not been recorded from any locality outside the Bay of Bengal.

Subfamily *MACROPHTHALMINAE.*

Macrophthalmus telescopicus (Owen).

1900. *Macrophthalmus Verrauxi*, Alcock, *Journ. As. Soc. Bengal* LXIX, p. 377.
1915. *Macrophthalmus telescopicus*, Tesch, *Zool. Meded. Leiden Mus.* I, pp. 161-164, pl. v, fig. 2.
1919. *Macrophthalmus telescopicus*, Kemp, *Rec. Ind. Mus.* XVI, pp. 387, 388, pl. xxiv, figs. 10, 11.
1934. *Macrophthalmus telescopicus*, Sakai, *Sci. Rep. Tokyo Bunrika Daigaku* (B) I, p. 320, pl. xviii, fig. 2.
1934. *Macrophthalmus telescopicus*, Balss, *Faune des Colonies Francaises* V, p. 522.

Two female specimens, one of which is ovigerous, collected by Drs. Prashad and Chopra on beach at low tide at Palaiow on the east coast of Doung Island, Mergui Archipelago are referable to the present species.

Kemp and Tweedie[2] have suggested that Tesch's *M. telescopicus* may possibly consist of more than one species. Both these authors have shown that in the characters of the male chela and in some other respects the species, as understood by Tesch, is not quite homogeneous.

M. telescopicus is represented in the Museum collection by examples from Mergui, Tavoy, Andamans, Gulf of Manaar and the Red Sea. The species has a very wide range of distribution extending from Hawaiian Islands in the Pacific to the east coast of Africa and the Red Sea. It has been met with in a number of localities in Japan also.

Macrophthalmus convexus Stimpson.

1900. *Macrophthalmus convexus*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 378, 379.
1915. *Macrophthalmus convexus*, Tesch, *Zool. Meded. Leiden Mus.* I, pp. 175-178, pl. vii, fig. 8.
1919. *Macrophthalmus convexus*, Kemp, *Rec. Ind. Mus.* XVI, pp. 389, 390, pl. xiv, fig. 2.

Two somewhat mutilated examples of the present species are in Prof. Meggitt's first collection from Maungmagan. They appear to be typical in every respect.

As stated by Tesch the carapace length in young individuals is distinctly more than half of the carapace breadth. Similarly the front appears to be somewhat broader in young specimens than in the adult forms.

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[1] Alcock, *Journ. As. Soc. Bengal* LXIX, p. 367 (1900); *Ill, Zool. Investigator, Crust,* pl. lxiii, figs. 2, 2*a* (1905).
[2] Tweedie, *Bull. Raffles Mus. Singapore* XIII, pp, 164, 165 (1937).

There are specimens of *M. convexus* in the Museum collection from Mergui, Andaman Islands and the Gulf of Manaar. The species is restricted to the eastern part of the Indo-Pacific area only, being known from the Hawaiian Islands and Tahiti on the east to the Gulf of Manaar between India and Ceylon on the west. It has been recorded from Japan also.

Macrophthalmus erato de Man.

1900. *Macrophthalmus erato*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 381, 382.
1915. *Macrophthalmus erato*, Tesch, *Zool. Meded. Leiden Mus.* I, pp. 179-181, pl. viii, fig. 9.
1919. *Macrophthalmus erato*, Kemp, *Rec. Ind. Mus.* XVI, p. 390.
1936. *Macrophthalmus eratus*, Shen, *Contrib. Inst. Zool. Nat. Acad. Peiping* III, pp. 70, 71.

There are seven specimens of the present species in Drs. Prashad and Chopra's collection from Mergui. Six of these are females (two ovigerous) and one young male.

The lower margin of the orbit has a very characteristic shape in this species. The claw in the male, as described by de Man[1] in detail, differs considerably from that of the female, but in some young males that we have examined from the Museum collection the claw is more or less of the female type. In a young male example from Chandipur on the Orissa coast (carapace length 4·75 mm., carapace breadth 6·5 mm.) the fingers are almost as long as the palm and have no lobe-like teeth on the cutting edges, all the teeth being minute and more or less uniform and the spine on the inside of the palm is hardly noticeable. As in all the females, there is a strongly-marked ridge on the outer surface of the palm more or less parallel to the lower border and running almost up to the tip of the fixed finger; this ridge is faintly discernable on the fixed finger in large males even. In another male of about the same size from the same locality the claws are typically like those of the male. In a third male (carapace breadth 6·5 mm.) from Jack and Una Island in the Mergui Archipelago the claws are still more interesting, for they are intermediate between the male and the female types. The fingers are longer than is usually the case in the male, the lobes on the cutting edges are less well developed and the ridge on the palm, though fainter than it is usually in the female, is fairly well marked throughout. The inner surface of the palm is less hairy and the spine is altogether absent.

In two very small males from Chandipur (carapace breadth less than 5 mm.) the claws are definitely of the female type.

In the single male example in the present collection (carapace breadth 5·3 mm.) the fingers are as long as the palm and are not arched; the teeth are minute and uniform; the musical crest, the spine on the inner surface of the palm and the usual pad of hairs are suppressed; and the ridge near the lower border of the palm is strongly marked up to the tip of the fixed finger. All these characters are typical of the female chela.

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[1] de Man, *Journ. Linn. Soc. London (Zool.)* XXII, pp. 125-129, pl. viii, figs. 12-14 (1887-1888).

It is thus seen that in the young examples of *M. erato* the claws are of one type only and that whereas this type is retained by the females throughout life, in males after attaining a carapace breadth of 6 mm. or a little more, a differentiation into what ultimately becomes the " male type " starts appearing.

Tweedie[1] has recorded the occurrence of the species in " burrows consisting of the bark of a burried mangrove twig from which the wood had rotted away ".

There is a large number of specimens of *M. erato* in the collection of the Indian Museum; all of these are from the Bay of Bengal. The species extends from Java and the Chinese coast on the east to the Orissa coast in India on the west.

Family GRAPSIDAE.

Subfamily *GRAPSINAE*.

Grapsus strigosus (Herbst).

1900. *Grapsus strigosus*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 393, 394.
1918. *Grapsus strigosus*, Tesch, *Siboga Exped. Rep.* XXXIXc, pp. 71-74, pl. iv, figs. 1 and 4.
1922. *Grapsus strigosus*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 147.

A large number of specimens of this species are in all the three collections under report.

Alcock and Tesch have enumerated the differences between this species and the closely allied *Grapsus grapsus* (Linn.). Our specimens are all typical examples of the present species.

In young individuals the length of carpus and propodus of the walking legs is more than the length of the merus; in older individuals, however, the two are generally equal.

Grapsus strigosus is a very common species in the Indian coastal waters, both in the Bay of Bengal and the Arabian Sea. It has a very wide range over the entire Indo-Pacific region, being met with from Polynesia to the east coast of Africa. The species possibly extends to the west coast of America[2] also.

Subfamily *VARUNINAE*.

Varuna litterata (Fabricius).

1900. *Varuna litterata*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 401, 402.
1922. *Varuna litterata*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, pp. 149, 150.

Only one female specimen of this widely-distributed species is in the first collection of Prof. Meggitt from Maungmagan. The species is met with in large numbers in estuaries and backwaters along the Indian coasts, and is frequently collected in places where the water is even quite fresh. Kemp[3] has described the " modes of invasion " of this

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[1] Tweedie, *Bull. Raffles Mus. Singapore XIII*, p. 164 (1937).
[2] Rathbun, *Bull. U. S. Nat. Mus.*, XCVII, p. 231 (1918).
[3] Kemp, *Mem. Ind. Mus.* V, pp. 232, 233 (1915).

species in order to establish itself in fresh water in the neighbourhood of Calcutta. The species has been frequently collected in the open sea also.

V. litterata has a very wide range of distribution; Balss gives it as: " In See-und Süsswasser, von der Ostküste Africa (nicht im roten Meere) bis zur Südsee; im eigentlichen Pazifik seltener."

Subfamily *SESARMINAE.*

Sesarma (Sesarma) taeniolata White.

1900. *Sesarma taeniolatum*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 419, 420.
1917. *Sesarma (Sesarma s. s.) taeniolata*, Tesch, *Zool. Meded. Mus. Leiden* III, pp. 201-203, pl. xvi, fig. 3.
1936. *Sesarma (Sesarma) taeniolata*, Tweedie, *Bull. Raffles Mus. Singapore* XII, p. 53.

A single male specimen, perhaps not fully grown, of this species is in Prof. Meggitt's first collection from Maungmagan.

The specimen shows all the characters enumerated by Tesch. The upper border of the arm ends in a somewhat blunt tooth. The distance between the external orbital angles of the carapace equals the distance between the epibranchial teeth. The breadth of the meropodites of the walking legs is a half or a little more than half of their length. The " tympana " mentioned by Tesch can only be faintly made out in the usual position.

Sesarma taeniolata is represented in the Indian Museum collection by specimens from the Bay of Bengal only. The species seems to be restricted to the eastern part of the Indo-Pacific region only.

Sesarma (Parasesarma) prashadi, sp. nov.

(Plate VI, figs. 5-7.)

The carapace is for the most part flat, though it is slightly convex in a longitudinal direction in the anterior part. The branchial regions, as usual, slope strongly downwards towards the margins. The regions are fairly well demarcated; the mesogastric lobe forms an independent convexity, with the anterior narrow longitudinal projection running forward for a short distance. The intestinal region also forms a convexity. There are seven or eight prominent oblique ridges, rather than striations, on the epibranchial regions, each ridge being microscopically beaded. The surface of the carapace is smooth, there being only a few low and blunt tubercles, with short, stiff hairs on them, scattered on the surface. The four post-frontal lobes run in almost a straight line; the inner lobes are about twice as broad as the outer lobes. The two inner lobes are separated from one another by a deep longitudinal groove, which runs for a considerable distance backwards. The groove between the outer and the inner lobes on each side is broad and V-shaped and is much shorter than the groove between the median lobes. All the four lobes are anteriorly rounded and those of the median pair are minutely rugose on the anterior aspect.

The carapace is distinctly broader than long, the median length being about three-fourths of the distance between the outer orbital angles, where the carapace is the broadest. The sides are somewhat convergent posteriorly, the breadth of the carapace at the postero-lateral angles being less than that at the outer orbital angles. The sides are straight in the anterior part, somewhat concave about the middle and bulge outwards posteriorly. The margins are entire and there is no tooth behind the acute external orbital angle; the latter is directed outwards and somewhat forwards.

The front (Plate VI, fig. 6), as usual, is very much deflexed. Its sides are more or less parallel and the anterior angles are broadly rounded. In dorsal view the anterior margin of the front forms a broad and shallow depression in the middle, with an anteriorly convex lobe on either side. Just close to the margin of each lobe there is a transversely oval tubercle with a single short stiff hair on it. In frontal view the anterior margin of the front is straight or slightly convex.

The orbits are markedly slanting. From the inner supra-orbital angle the upper orbital border comes more or less directly backwards, but from about the level of the posterior limit of the thick eye-stalk it runs backwards and outwards, in its last part, near the lateral margin of the carapace the orbital border runs directly outwards. For the most part this border forms a broad regular curve, but a portion about the middle is somewhat convex. The lower orbital border is prominent, and a part of it is visible in dorsal view. The lower border is finely beaded.

The chelipeds are unequal, that on the right side being distinctly longer and stouter than that on the left. The arm is trigonous, with all the three border cristiform and beaded. The outer surface of the arm is covered with squamiform granules, while the inner and lower surfaces are smooth. The inner border is distally expanded and terminates in a large, broad-based and pointed spine. There is no subterminal spine on the upper border. The outer surface of the wrist is only faintly granular, though it has squamiform markings; the inner angle is broad and obtuse. The palm is swollen and is markedly high, the length of the propodus (palm and fixed finger) along the lower margin being only one and a half times of its height. The upper border is very short and finely beaded. The outer surface of the palm is quite smooth, though there are a few indistinct squamiform markings arranged in irregular lines near the carpal joint, and a few stiff hairs scattered about. The inner surface is more or less smooth with a few isolated granules scattered in the distal portion. The lower border of the palm is denticulate, the denticulation extending up to about the middle of the fixed finger. The usual chitinous pectinated ridges are arranged transversely near the upper border of the palm, and more or less parallel to its posterior border. The anterior or the distal-most ridge is quite straight, the second is somewhat sinuous, while the third, which is more or less obsolete, consists of only a few pectinations and some granules. The teeth in the first ridge are so closely arranged, more or less like the teeth of a very fine comb, that it is difficult to count them, but there appear to be at least 40 of these. In the second ridge the teeth are

less high and their number is also smaller. The fingers are stout and gape only slightly at the base. The lower border of the fixed finger is somewhat concave near the base. The dactylus is as long as the height of the palm and tapers gradually towards the tip. The cutting edge has seven or eight blunt teeth, the proximal-most of which is the largest. The fixed finger has only five teeth arranged on about the distal half of the cutting edge and, as in the dactylus, the most proximal tooth is the largest. The tips are broadly pointed, hollowed and almost spoon-shaped. The outer surface of the dactylus is profusely granular near the base. On the upper border of the dactylus (Plate VI, fig. 7), slightly on the outer aspect, there is the usual row of transverse tubercles extending from the base to almost the tip. Each tubercle, except in the distal part, is in the form of a narrow oval dome, with a median, somewhat smooth longitudinal ridge. The tubercles are quite symmetrical with respect to their long axes. Near the base of the finger they are small and crowded together, but the distance between them increases distally and near the tip they again become small, almost squarish and are widely separated from one another. The most distal ones, quite close to the tip, are indistinct, but 27 of them can be counted on the large claw. On the inside of this row of tubercles the basal half of the upper border of the dactylus is densely studded with largish granules. The smaller chela differs from the larger one only in size.

The merus of the walking legs is broad, that of the third pair being two and a half times as long as broad. The posterior margin of the merus is entire, but the anterior has a subterminal sharp spine. In the first three pairs the merus has prominent squamiform markings on the upper surface. The carpus has two, more or less, longitudinal ridges on its upper surface, one about the middle and the other close to the anterior margin. The propodus also has one ridge running obliquely from about the middle at the proximal end to the posterior margin at the distal end. The dactylus is large and sharply pointed; in the first three legs it is almost as long as the propodus, but in the last leg it is longer than the preceding segments. The last three segments are sparsely clothed with short stiff hairs on the margins.

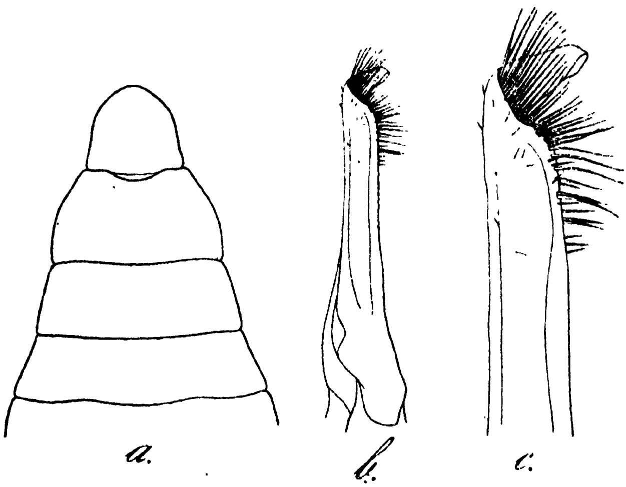
As usual in the genus the abdomen of the male (text-figure 20*a*) is somewhat broad and occupies the whole breadth of the sternum between the bases of the last legs. The terminal segment is short and broadly rounded; its basal breadth is a little more than its median length. The sixth segment is very slightly shorter than the seventh and is almost half as long as its breadth at the posterior margin. The fifth segment is shorter than the sixth and its posterior breadth is a little less than three times of its median length. The sides of the abdomen are somewhat concave.

The anterior abdominal appendages of the male are rather short and stout and the tip is sharply bent outwards. There is a dense growth of long hairs on the outer margin behind the tip.

The carapace and legs in the single specimen preserved in spirit that we have examined are of a dull mottled purplish colour; the chelipeds are pale and the fingers light orange. The sternum and the ventral surface of the legs are lighter than the dorsal surface.

Type-specimen.—C 2296/1, Zoological Survey of India (*Ind. Mus.*).

Locality.—The single specimen on which the present species is based was collected in a small freshwater stream, quite near the sea-shore, at Kamachaung, a small village on the east coast of Doung Island in the



TEXT-FIG. 20.—*Sesarma* (*Parasesarma*) *prashadi*, sp. nov.

a. Terminal part of male abdomen : × 7. *b*. First left pleopod of male : × 13, *c*. Tip of the same enlarged : × 30.

Mergui Archipelago, by Drs. B. Prashad and B. N. Chopra on 19th January, 1937. The water at the place where the specimen was obtained tasted quite sweet, but may possibly have been subject to the influence of the tides.

The measurements, in millimetres, of the male specimen of *S. prashadi* are given below, and, for purposes of comparison, the corresponding measurements of a male specimen of *S. plicata* (Latreille) from Burma are included.

	S. prashadi ♂	*S. plicata* ♂
Length of carapace	9·2	10·5
Distance between external orbital angles	12·2	13·2
Distance between postero-lateral angles of carapace ...	10·3	12·0
Breadth of front	6·3	7·5
Breadth of carapace at posterior margin	5·1	6·3
Length of palm and fixed finger (larger claw) along lower border	9·3	7·8
Height of palm (larger claw)	6·1	4·4
Length of dactylus (larger claw) along upper border ...	6·1	4·8
Length of upper border of palm (larger claw) ...	3·9	2·8
Length of merus of 3rd walking leg	7·8	8·5
Breadth of merus of 3rd walking leg	3·2	3·8
Median length of 5th abdominal somite of male ...	1·4	1·7
Posterior breadth of 5th abdominal somite of male ...	4·0	4·6
Median length of 6th abdominal somite of male ...	1·6	1·7
Posterior breadth of 6th abdominal somite of male ...	3·3	3·9
Median length of 7th abdominal somite of male ...	1·7	2·3
Posterior breadth of 7th abdominal somite of male ...	1·9	2·3

That *Sesarma prashadi* belongs to the subgenus *Parasesarma* of de Man is clearly seen by the fact that the lateral margins of the carapace are not dentate behind the external orbital angles, that the upper surface of the palm has two or three transversely arranged pectinated ridges, and that the upper border of the dactylus has a row of transverse tubercles. In the key given by Tesch[1] for the identification of the Indo-Pacific species of *Parasesarma* the present species—in so far as there are no spines on the posterior border of the meropodites of the walking legs, the sides of the carapace converge distally and the tubercles on the upper border of the dactylus are symmetrical with respect to their long axes—seems to come close to *Sesarma plicata* (Latreille), which name Tesch,[2] presumably on the authority of Miss Rathbun, has given to the species so far known to most carcinologists as *Sesarma quadratum* (Fabricius). There are, however, some noteworthy differences between these two species. In the new species the carapace is a little more convex, the regions are a little more distinct, the outer post-frontal lobes are considerably smaller than the inner and the front, as compared with the carapace breadth, is a little narrower. Further the upper margin of the arm does not end in a spine, the inner angle of the wrist is broader than in *plicata*, the palm is considerably higher, its outer surface is less granular and the inner less tuberculate. The number of teeth in the pectinated ridges on the palm is also very much larger in the new species. The number of tubercles on the upper border of the dactylus is about 27 in our species, whereas in *S. plicata* there are usually 12-14 tubercles, though the number may vary between 11 and 18 or even rarely 19. The proportions of the last three abdominal segments of the male are also different in the two species and the anterior male abdominal appendages are not quite similar. A comparison of the measurements of *S. prashadi* with those of *S. plicata* given on p. 429, and of the figures of the male abdomens and the male appendages of the two species will bring out most of these points.

In having 20 or more tubercles on the upper border of the movable finger the present species shows some resemblance to *S. erythrodactyla* (Hesse)[3] and *S. bataviana* de Man.[4] In both these species, however, the tubercles are not symmetrical with respect to their long axes and are prominently striated longitudinally. There are several other differences also. *S. melissa* de Man[5] has also a superficial resemblance with *S. prashadi*, but besides other differences, the number of tubercles on the dactylus in de Man's species, is smaller and the tubercles are asymmetrical. In *Sesarma* (*Parasesarma*) *obliquifrons* Rathbun[6], described from Samoa, the general shape of the front and the hands is more or less like that in our new species, but the differences between the two species are far more numerous than these points of superficial similarity.

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[1] Tesch, *Zool. Meded. Mus. Leiden* III, pp. 251-255 (1917).
[2] Tesch, *op. cit.*, pp. 187-190; see foot-note 3 on p. 187.
[3] See Tesch, *op. cit.* p. 149 (1917).
[4] See Tesch, *op. cit.*, p. 132.
[5] See Tesch, *op. cit.*, p. 174.
[6] Rathbun, *Proc. Biol. Soc. Washington* XXXVII, pp. 127, 128 (1924).

S. prashadi seems to show the closest resemblance to the species recently described by Tweedie[1] under the name *Sesarma* (*Parasesarma*) *rutilimana* from a small island near Singapore. The points of similarity are clearly seen by comparing our description of the new species with that given by Tweedie for his. There are, however, some noteworthy differences between the two. *S. prashadi* appears to be a somewhat broader form than the Singapore species and, unlike the latter, has unequal chelipeds. There are three (two distinct and one obsolete) pectinated ridges on the outer surface of the palm and the first of these has over 40 teeth ; in Tweedie's species there is only one ridge having rather more than 20 teeth. Further the tubercles on the dorsal surface of the distal half of the movable finger, in *S. rutilimana*, become elongated, asymmetrical, with the longer proximal slopes striated : in our species they become squarish distally, but, are all symmetrical and are not striated. The colouration of the two species is also markedly different. The two species in our opinion, in spite of their very close similarity, must, therefore, be considered distinct.

Sesarma (Chiromantes) bidens (de Haan).

1900. *Sesarma bidens*, Alcock, *Journ. As. Soc. Bengal* LXIX, p. 415.
1917. *Sesarma* (*Chiromantes*) *bidens*, Tesch, *Zool. Meded. Mus. Leiden* III, pp. 132-135.
1922. *Sesarma* (*Chiromantes*) *bidens*, Balss, *Arch. Naturgesch.* LXXXVIII, Heft 11, p. 156.

In our collection there are examples of the present species from Maungmagan (Prof. Meggitt's first collection) and from a fresh-water stream near Mergui (Drs. Prashad and Chopra). The specimens are quite typical.

In the Museum collection there are specimen of *S. bidens* from a number of localities in the Bay of Bengal. The species has a very wide range of distribution being known from Australia and New Guinea to the east coast of Africa. It is one of the commonest species of *Sesarma* in Japan.

Clistocoeloma merguiense de Man.

1900. *Clistocoeloma merguiense*, Alcock, *Journ. As. Soc. Bengal* LXIX, p. 429.
1917. *Clistocoeloma merguiense*, Tesch, *Zool. Meded. Mus. Leiden* III, p. 222.
1936. *Clistocoeloma merguiense*, Tweedie, *Bull. Raffles Mus. Singapore* XII, p. 68.

A single specimen referable to de Man's species is in the present collection. It was collected in a small fresh-water stream on a small Island in the Mergui Archipelago. The place from which the specimen was obtained is probably subject to a certain extent to tidal influence.

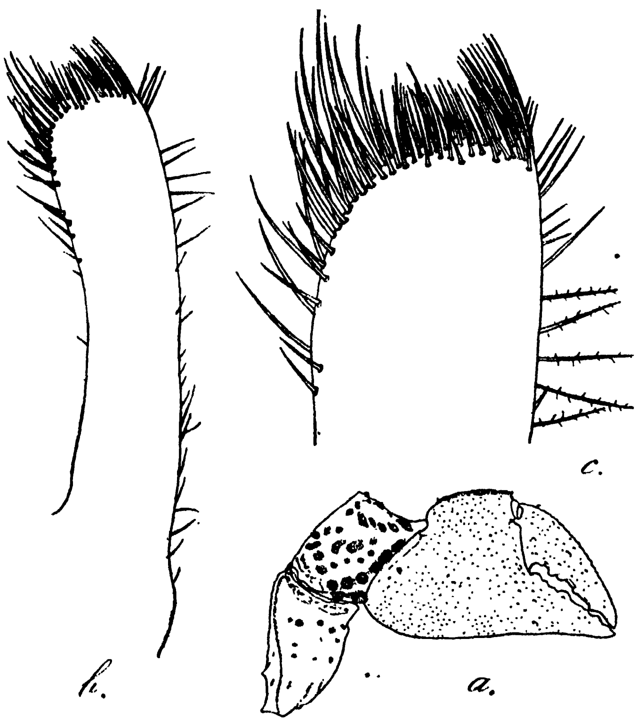
C2297/1	A small fresh-water stream at Kamachaung on the east coast of Doung Island, Mergui Archipelago	Drs. B. Prashad and B. N. Chopra, 19th Jan., 1937	1 ♂

The specimen agrees very closely with the detailed description given by de Man,[2] as also with the named examples in the Museum collection

[1] Tweedie, *Bull. Raffles Mus. Singapore* XII, pp. 63-65, pl. xv, fig. 2 (1936).
[2] de Man, *Journ. Linn. Soc. London* (*Zool.*) XXII pp. 195, 196, pl. xiii, fig. 10 (1888).

identified by Alcock. The key given by Tesch (*op. cit.*, p. 259) for the recognition of this species is very helpful. The abdomen of the male, as mentioned by de Man, is very much like that of *C. balansae* A. M.-Edwards.[1] the genotype, and differs considerably from that *C. tectum* Rathbun, as described and figured by Tesch (*op. cit.*, pp. 224, 225, pl. xvii, fig. 3*c*). The chelipeds in our specimen are also as described by de Man.

The anterior male appendages are as shown in the accompanying text-figure. They are short and stumpy and are broadly truncate at the tip, which is densely hairy.



TEXT-FIG. 21.—*Clistocoeloma merguiense* de Man.

a. Cheliped of male : × $3\frac{2}{3}$. *b*. Anterior left pleopod of male : × 22. *c*. Tip of the same enlarged : × 47.

The measurements, in millimetres, of the Mergui specimen are as given below :—

Length of carapace	11·3
Distance between external orbital angles	12·8
Breadth of front	8·2
Length of claw (palm and fixed finger) along lower border	9·2
Height of palm	6·0
Length of dactylus along upper border	6·1
Median length of 4th abdominal somite of male	1·3
Median length of 5th abdominal somite of male	1·6
Median length of 6th abdominal somite of male	1·4
Posterior breadth of 6th abdominal somite of male ...	4·1
Median length of 7th abdominal somite of male	2·8
Posterior breadth of 7th abdominal somite of male ...	2·2

[1] A. Milne-Edwards, *Nouv. Arch. Mus. Paris* IX, p. 311, pl. xvii, fig. 1 (1873).

C. merguiense is known mostly from the Bay of Bengal only, having been recorded from Penang, Mergui Archipelago and Nicobar Islands; the only record outside the Bay is that of de Man from Amboina Island.

Owing to the carapace being "symmetrically and boldly lobutated" Tesch (*loc. cit.*, foot-note) is of the opinion that the specimens which Alcock referred to *C. balansae* really belong to Miss Rathbun's *C. tectum.* We have carefully re-examined these specimens and though we have no examples of *C. tectum* to compare them with, we have checked them with the published descriptions of the species and especially with the detailed account given by de Man.[1] We are of the opinion that Alcock's specimens cannot be referred to *C. tectum* and that they have been rightly identified as *C. balansae.* In the form of the upper orbital border and the proportion of the abdominal segments of the male, to mention only the two characters especially stressed by Tesch for the identification of the species of *Clistocoeloma*, the Indian Museum specimens show their close similarity with Milne-Edward's species. We give here a figure (text fig. 15*d*, p. 414) and measurements, in millimetres, of the male abdomen of one of Alcock's specimens of *C. balansae*, and a comparison of these with the similar figure and measurements of *C. tectum* given by Tesch will show that they are not referable to Miss Rathbun's species. The curvature in the upper orbital border is perhaps not so well pronounced as mentioned by de Man, but it can still be clearly seen.

Median length of 4th abdominal segment of male ...	...	1·6
Median length of 5th abdominal segment of male ...	...	1·9
Median length of 6th abdominal segment of male ...	...	1·7
Posterior breadth of 6th abdominal segment of male	...	4·5
Median length of 7th abdominal segment of male ...	...	3·2
Posterior breadth of 7th abdominal segment of male	...	2·4

In the character of the lobulation of the carapace, it must be admitted that Alcock's specimen of *C. balansae* comes very close to *C. tectum.* The number and arrangement of the tubercles on the dorsal surface of the carapace in the Indian Museum specimens is more or less identical with that described and figured by Tesch for *C. tectum.* The length of the carapace also equals the distance between the outer orbital angles and the outer post-frontal lobe is subdivided into two by a longitudinal fissure, but these characters, as mentioned by Tesch, are common to both the species.

Metaplax dentipes (Heller).

1900. *Metaplax dentipes*, Alcock, *Journ. As. Soc. Bengal* LXIX, pp. 433, 434.
1918. *Metaplax dentipes*, Tesch, *Siboga Exped. Rep.* XXXIXc, p. 117, foot-note.

Two males of this species are in Prof. Meggitt's first collection from Maungmagan and four males were collected by Drs. Prashad and Chopra in Bockachaung, a freshwater stream near Mergui.

[1] de Man, *Zool. Jahrb. Syst.* IX, pp. 340-343 (1896).

The specimens agree very closely with our named examples. The dactylus of the chelipeds may sometimes be a little longer than the upper border of the palm. In one example from Maungmagan the chelae are unequal.

Metaplax dentipes is a common coastal form in the Bay of Bengal. Tesch gives its distribution as the Gulf of Siam, Mergui Archipelago, Ceylon and the Indian (eastern) coast.

EXPLANATION OF PLATE VI.

FIG. 1.—*Heteronucia mesanensis* Rathbun, dorsal view of the female specimen from Mergui : ×8.

FIG. 2.—*Chlorodiella niger* (Forskäl), dorsal view of the carapace of a young female :×7.

FIG. 3.—*Pilumnus longicornis* Hilgendorf, dorsal view of a specimen from Mergui :×2.

FIG. 4.—*Litocheira angustifrons* Alcock, dorsal view of a male specimen from Karachi :× 1½. One side of the carapace has been denuded.

FIG. 5.—*Sesarma* (*Parasesarma*) *prashadi*, sp. nov., dorsal view of the type specimen :× 2.

FIG. 6.—Frontal view of the carapace of the same :× 4.

FIG. 7.—Large cheliped of the same :× 7. The arrangement of the tubercles on the dactylus is seen.

Subodh Mondul Photo

CRABS FROM TAVOY AND MERGUI.

STRUCTURE, HABITS AND EARLY DEVELOPMENT OF A NEW SPECIES OF *STILIGER* EHRENBERG.

By K. Virabhadra Rao, *B. Sc.*, (Hons.), *M. Sc.*

(From the University Zoological Research Laboratory, Madras.)

(Plates VII—IX.)

Contents.

	Page.
Introduction	435
Material and Methods	436
History of the Genus *Stiliger*	436
External features of *Stiliger gopalai*, sp. nov.	438
Digestive System	440
Circulatory and Respiratory Systems	443
Renal System	443
Nervous System and Sense Organs	444
Reproductive System	447
Breeding and Spawning habits	451
Notes on Development	452
Behaviour of the Animal in respect of Variations in Salinity	456
Systematic Position of the Animal	457
Summary	458
Bibliography	459
Key to Lettering	462

Introduction.

While engaged in faunistic studies of the brackish waters of Madras, Professor R. Gopala Aiyar drew my attention to the occurrence of a small Eolid-like Mollusc. An examination of the brackish water pools near the mouths of the rivers Cooum and Adyar in Madras during August and September 1935, revealed this tiny Mollusc creeping on algae floating in the waters. A careful study of its external characters and anatomy convinced me that it was a new species of the genus *Stiliger* Ehrenberg, and a preliminary note on this form was read by me before the Zoology Section of the Indian Science Congress held at Indore in the month of January 1936.

Though the genus was discovered as early as 1831, our knowledge of its anatomy is incomplete in most respects while nothing is known about its life-history. I have therefore given in this paper a full description of the external morphology and internal anatomy of this new form, which I have named *Stiliger gopalai*, sp. nov., and a brief account of the bionomics and development. *Stiliger gopalai* is a hardy form and affords good scope for study under laboratory conditions. Captivity affects neither its normal activities nor its breeding habits.

O'Donoghue (**43**). Vayssiere (**59**) treated *Ercolania* as a separate genus; and Bergh[1] and Eliot (**20**) have described new species of *Ercolania*. In my view the genus *Ercolania* is distinct from *Stiliger* in that the former has canaliculated grooves in the rhinophores. This character, though minute, is quite distinct, and a similar difference in the nature of the rhinophores also distinguishes *Hermaea* from *Stiliger*.

EXTERNAL FEATURES OF *Stiliger gopalai*, sp. nov.

The animal (Pl. VII, figs. 1, 2 and 5) has the general appearance of an Eolid and measures when fully expanded 11 to 12 mm. in length and 4 to 4·5 mm. in breadth. The ground colour is deep brownish gray speckled with yellow here and there. The yellow colour completely disappears on preservation and the depth of the gray varies with the physiological condition of the animal. When kept in captivity without food for a couple of days, the gray fades into a pale colour. The dark gray colour of the dorsal part of the snout is striking with a pale yellow streak running on either side of this area beginning from the base of the dorsal tentacle and extending up to the anteriormost cerata. The rest of the dorsal surface and the sides are finely spotted yellow with the region surrounding the anus slightly pale. The yellow spots are very minute in the anterior half of the back and comparatively large in the posterior half.

The snout, 1·75 mm. in length, is more or less convex dorsally, and slightly notched in the anterior middle region over the mouth giving the appearance of two minute lumps, one on either side, which represent the thickenings of the outer lips (Pl. VII, fig. 3, *la.*). The snout bears antero-dorsally a pair of smooth, long, slender and pointed tentacles or rhinophores measuring about 3 to 3·25 mm. in length. A pair of dark, minute eyes is seen through the transparent integument covering the neck region behind the dorsal tentacles.

The part that follows the neck is conspicuously broad and bears the dorsal papillae or the cerata, which are arranged in two longitudinal bands, one on either side of the back leaving the middle region bare throughout its length. Each band appears at first sight to consist of two or more rows of cerata, but as in *Stiliger bellulus* the arrangement is irregular. The cerata are 3 mm. long, neither very slender nor very much inflated. They are dark gray with distinct white tips, and reveal all over their surface microscopical white dots representing the gland cells (Pl. VII, fig. 4, *o. gl.*). Such gland cells are also seen at the bases of the rhinophores. Each band consists of thirty to forty cerata, of which, as a rule, the anterior ones are the smallest and the posterior the longest; but the autotomy of these organs and their subsequent regeneration are so common that small and minute cerata may appear occasionally at any region in the band. The hepatic ramifications (*d. gl. r.*) extending into the cerata show only one main stem which gives off but a few minute branches. When the animal is disturbed the gland cells secrete a copious, whitish, slimy, pungent-smelling fluid, and the

[1] **Beitr. Z. Kennt. der Aeolidiaden**—***Ver. k.k. Zool. Bot. Gessel. Wien.*, V, (1878) referred by Eliot (20).**

cerata break off spontaneously as in *Tergipes* and *Galvina*. The cerata thus cast off swim freely in water in all directions by means of their cilia and may continue to be active for nearly a week.

The foot, which is 1 mm. wide, is considerably narrower than the back and extends from one end of the body to the other, tapering posteriorly into a fine filamentous tail nearly as long as the rhinophore. It is pale yellow in colour and bears a few minute, yet distinct, white spots.

The middle of the anterior region of the foot is slightly grooved with its antero-lateral edges rounded into two small lobes. The narrow foot seems to be adapted to the habit of creeping on filamentous algae (*Chaetomorpha*) which form its chief food. Movements of the animal from place to place are effected by waves of muscular contractions characteristic of all Gastropods. When the animal creeps from one filament of the alga to another lifting up the anterior part of the body, the muscular contractions of the foot are clearly seen in the region which is raised above the substratum. The cilia of the foot are in constant action but they only play a secondary part in the locomotion of the animal.

The mouth, a vertical slit, is anterior and median and lies immediately above the median cleft of the foot; and the anus (Pl. VII, fig. 1, *an.*), which opens out to the exterior on a minute papilla, is dorsal and median, lying in front of the pericardium. The genital openings are three in number and are situated on the right side of the body in the neck region. Of these the male genital or the penial opening (Pl. VII, fig. 5, *op. pen.*) lies foremost immediately beneath the right eye. The second in order is the oviducal opening (*op. ov.*) for the purpose of spawning, which lies close behind the male genital opening. The third, the vaginal (*op. va.*), is situated some distance from the other two beneath the first or the second cerata of the right side. The ampulla of the vagina, which lies closely pressed to the integument, shows an external demarcation as a pale white scar behind the vaginal opening.

Histology of the Body-Wall and the Foot.—The body-wall is thin, soft and smooth and consists of an outer ectodermal epithelium of varying thickness formed of pigment cells. The pigment is, however, absent in the cells lining the labial folds and the region immediately surrounding the anus. The lining epithelium of the rhinophores, the labial folds and the cerata is provided with vibratile cilia, but that of the back and the sides is without any cilia. Associated with the dermal epithelium are seen two types of glands, *i. e.*, the mucous and the odoriferous glands. The mucous glands are either unicellular or multicellular and stain darkly with haematoxylin. The comparatively large-sized, flask-shaped odoriferous glands are multicellular and are particularly numerous in the head region at the bases of the rhinophores and all over the cerata. They lie beneath the epithelium and open to the exterior by short necks. Beneath the dermal epithelium there is a loose connective tissue traversed by muscle fibres and blood sinuses.

The foot (Pl. VIII, fig. 1) has an outer ciliated epithelium of columnar ciliated cells (*ci.c.*) with a thin cuticle separating the cells from the cilia. Beneath this epithelium lies the dermal connective tissue penetrated

by muscle strands (*m.f.*) and blood sinuses. The mucous glands are either unicellular (*m.g.*) and interspersed between the epithelial cells, or multicellular (*m.m.g.*) and sub-epithelial. They open to the exterior through minute crypts (*cr.*) and secrete a copious quantity of mucus which aids the animal to creep easily on any substratum or to cling to the surface of water with the ventral side upwards.

DIGESTIVE SYSTEM.

The digestive system of *Stiliger* was first studied in *S. bellulus* by Milne-Edwards (**19**). He observed a number of ramifications of the gut in the dorsal papillae and other external organs, and believed that there was a definite communication of the digestive organs with the vascular system in those regions. He accordingly termed this apparatus, the gastro-vascular system, which, as remarked by Alder and Hancock (**6**), " he compares to the system of vessels radiating from the stomach of the *Medusidae* on the one hand, and to the caeca connected with the digestive organs of the *Nymphons* among the *Crustacea* on the other." The work of Quatrefages (**48**) on *Eolidina paradoxum* confirmed the results obtained by M.-Edwards. His (**49, 50**) further investigations on the subject led him to establish the Order Phlebenterata, to include certain forms allied to *Stiliger* such as *Acteonia*, *Chalidis* etc., which were supposed to exhibit what he called ' phlebenterism '. He believed that the members of this order suffered a very great deterioration of the vascular system, the heart and the blood vessels being completely absent, and that the digestive system was likewise modified. He believed that the anus was absent in all these forms, and that the alimentary system discharged the double function of digestion and circulation. The researches of Alder and Hancock, and of Souleyet and others did not confirm Quatrefages' observations. After much controversy over the subject, the Biological Society of Paris proved definitely that the conclusions arrived at by Quatrefages were erroneous and that in all the Phlebenterata there is a definite circulatory system independent of the organs of digestion.

In *Stiliger gopalai* the mouth is a narrow slit placed on the inferior side of the head and bounded by a pair of fleshy lips (Pl. VII, fig. 3, *la.*), which are continuous with each other except for the presence of a deep furrow running in the median line above the mouth. The ectodermal epithelium of the lips is ciliated and is invaginated evenly into a short and narrow passage, the channel of the mouth. The epithelium (Pl. VIII, fig. 2, *epi.*) of the channel of the mouth has a number of small crypts (*cr.*) along which the numerous club-shaped glands (*b.gl.*) of varying sizes open by their slender ducts. These glands correspond to the buccal or oral glands of Opisthobranchiata described by several authors. Posteriorly the channel of the mouth leads into a pale white, muscular organ, the pharyngeal bulb or the bucco-pharynx (Pl. VII, fig. 7 and Pl. VIII, fig. 3, *ph.*), 0·7 mm. long, 0·6 mm. high. This organ, which is suctorial in function, is provided with a radula and an ascus (*as.*) and receives the discharge of a pair of salivary glands (*s.gl.*). The lumen of the pharyngeal bulb is lined by an epithelium of columnar

non-ciliated cells, the secretion of which forms a thin cuticle lining the entire interior of the pharyngeal bulb.

At the base of the lips and guarding the entrance to the mouth there is a ring of circular muscles acting as a sphincter. From this region several strands of muscles forming the anterior retractors pass backwards to be attached to the anterior region of the pharyngeal bulb. The paired posterior retractors of the pharyngeal bulb proceed backwards from its sides to the foot. By the action of these two sets of muscles the pharyngeal bulb moves backwards and forwards.

The radula (Pl. VIII, fig. 4) measuring 0·6 mm. in length lies ventrally in the pharyngeal bulb. It is of the uniseriate type characteristic of all Ascoglossa. It shows (i) a straight ascending axis bearing five well formed teeth and one growing tooth surrounded by odontoblasts in a short horizontally placed radular sac, (ii) a descending axis of seven teeth proceeding towards the ascus and (iii) the ascus itself, a minute pouch antero-ventral to the pharyngeal bulb and containing a small heap of about twenty worn out teeth. Throughout the life of the animal the odontoblasts in the radular sac continuously secrete material for the formation of fresh teeth, while the worn out teeth are being stored in the ascus. The teeth (Pl. VIII, fig. 5) are all of the same shape and size. Each tooth is 0·125 mm. long, and has a wavy margin. One half of the tooth bears a spoon-shaped depression into which the tooth behind closely fits. The teeth closely resemble those of *Stiliger varians* and *Ercolania siottii*. On comparing the radula of this form with that of *S. bellulus* (syn. *S. mariae*, Bergh 1872, Taf. 26, fig. 6) we find that in the latter the descending axis is spirally coiled and shows a larger number of teeth, broad at their bases and narrow and pointed at their apices.

The animal possesses a pair of slender salivary glands (Pl. VII, fig. 7, and Pl. VIII, fig. 3, *s.gl.*) measuring about 1·1 mm. in length and 0·1 mm. in thickness. The great development of the anterior genital complex on the right side has pushed the glands to the left of the oesophagus. A pair of narrow salivary ducts nearly as long as the glands, and 0·017 mm. thick, pass through the nerve collar and open into the pharyngeal bulb, one on either side of the oesophagus. The gland (fig. 6) is composed of large cells (*gl.c.*) with small ciliated interstitial cells (*ci.c.*) wedged in between. The glandular cells are cubical, highly vacuolated and contain a large number of granules. The secretion of the gland is poured into the central lumen and is driven forwards by the ciliary action of the interstitial cells. The duct of the gland is formed of an inner layer of low ciliated cells and an outer layer of thin fibrous tissue.

The oesophagus (Pl. VII, fig. 7, and Pl. VIII, fig. 3, *oe.*), a thin semi-transparent slender tube 1·2 mm. long, starts from the postero-dorsal region of the pharyngeal bulb (immediately behind which it is encircled by the central nervous system) and running backwards beneath the spermatheca communicates with the stomach (*st.*). It has an inner layer of tall columnar ciliated cells and a thin outer muscular layer. There is no oesophageal caecum as in *Elysia viridis*. Souleyet (57) figured a caecum in *S. souleyeti* describing it as the first stomach. Neither Bergh nor Eliot has described an oesophageal caecum in any of the species of *Stiliger*.

The thin-walled and roughly triangular stomach (*st.*) which is shorter and wider than the oesophagus, lies medially above the ampulla of the hermaphrodite duct and in front of the pericardium. The inner wall of the stomach is longitudinally plicated and lined by a layer of low columnar ciliated cells. The stomach receives its nerve supply from the gastro-oesophageal plexus formed by the anastomosis of gastro-hepatic and gastro-oesophageal nerves from the visceral and the stomato-gastric centres respectively. A pair of diverticula (Pl. VII, fig. 7, *di.*) opens posteriorly into the stomach, one on either side ; and each of these gives two caecal prolongations (*ca.*), anterior and posterior, running along the sides of the body. These caecal prolongations in their turn communicate with the glandular ramifications (*d.gl.r.*) of the digestive gland present in the cerata. The lining of the diverticula and of the caecal prolongations is ciliated like that of the stomach, but has no folds, and its cells are very short.

The ramifications of the digestive gland of *Stiliger* penetrate into the cerata as in the allied genera *Hermaea* and *Ercolania*. In *S. gopalai* there is only a single main stem in each of the cerata (Pl. VII, fig. 4, *d.gl.r.*), with but a few minute short branches. In *S. bellulus* and *S. tentaculatus* a number of fairly long branches fill up the large space in the cerata. The digestive gland is grayish green in life, and though very much diffuse it has the same histological structure as in *Kalinga ornata* (Rao, **52**). The glandular epithelium (Pl. VIII, fig. 7) lining the ramifications, projects in the form of folds into the central lumen (*l*) and is formed of tall columnar and short cubical cells. The latter are few in number. Their cytoplasm is vacuolated and contains granular inclusions (*gr.*) of several kinds. The digestive gland in Mollusca is a hepato-pancreas, but it is supposed to discharge the function of excretion also.

The short intestine (Pl. VII, fig. 7, *int.*), 0·5 mm. long, arising antero-dorsally from the stomach, proceeds upwards and is continued as an extremely short rectum to the anus situated medially on the dorsal body wall in front of the pericardium. The intestinal walls are composed of an outer fibrous layer of sparse musculature and an inner glandular layer of tall columnar ciliated cells. The rectum does not differ to any extent from the intestine in histological structure.

S. gopalai, like the rest of the members of the Sub-Order Ascoglossa, is a vegetable feeder. Even in captivity the animal feeds voraciously on *Chaetomorpha* only, preferring starvation to feeding on other algae. In the act of feeding it rests on a thread of alga and applying its mouth to one of the cells, punctures it with the outermost tooth of the radula. This is brought about by the contraction of the anterior retractor muscles, which shortens the channel of the mouth. Immediately after the puncture is made the suctorial pharynx begins to work emptying the contents of the cell. When the feeding animal is watched under a binocular microscope, the pharyngeal bulb is seen through the translucent skin to contract and expand very rapidly sucking in the juice and driving it through the oesophagus into the stomach and the caecal prolongations of the digestive system. After emptying one cell of the algal thread it moves on to the next and repeats the same process. When young specimens without much pigment or the pale semi-starved

adults are watched under the binocular microscope after feeding on the algae for about a quarter of an hour the course of the gut is clearly seen through the integument because of the bright green colour of the algal juice. It is also observed that the cerata expand and contract independently of one another driving the contents of the caecal prolongations into the ramifications of the digestive gland and back again into the former. The sphincter at the base of each of the cerata controls this action.

CIRCULATORY AND RESPIRATORY SYSTEMS.

The organs of circulation are very simple and consist of the heart, the blood vessels and the blood sinuses. The heart (Pl. VIII, fig. 8) is a two-chambered muscular organ consisting of an auricle (*au.*) and a ventricle (*v.*) enclosed in a thin transparent membranous sac, the pericardium (*pe.*). The oval pericardial chamber, about 2·25 mm. long lies behind the anus, immediately beneath the dorsal body wall. As is common in all Mollusca, it is coelomic in origin. It communicates with the renal organ by the reno-pericardial opening (*r.p.o.*) situated posteriorly on the right side. Through the semi-transparent wall of the dorsal surface the heart is seen to pulsate about forty times per minute. The walls of the auricle and the ventricle in the live animal are thin, muscular and transparent. There is no endothelial lining to the auricle or the ventricle. The auricle receives several minute veins (*vei.*) posteriorly and pumps the blood into the ventricle. The auriculo-ventricular opening is provided with a pair of valves, which prevent the flow of blood back into the auricle when the ventricle contracts. The aorta arises from the anterior part of the ventricle and runs forward supplying blood to all the visceral organs and the foot, from which it is brought into the general body cavity. From the general body cavity, which is a haemocoel in all Gastropods, the blood enters into a number of sinuses in the integument and the cerata. The blood brought to these organs is aerated and is collected by various small veins which join together to form a few main trunks that open into the auricle.

The function of respiration is performed by the entire integument and the cerata. The sinuses, filled with blood present in these organs, are bounded by loose connective tissue and are separated from the exterior only by a thin dermal epithelium. Aeration takes place effectively in these organs. The cerata do not, however, discharge exclusively the function of respiration as when all the cerata are lost the animal remains normally active. For this reason, some authors prefer the term dorsal papillae to cerata, which is a near approach to the ctenidium or the true gill.

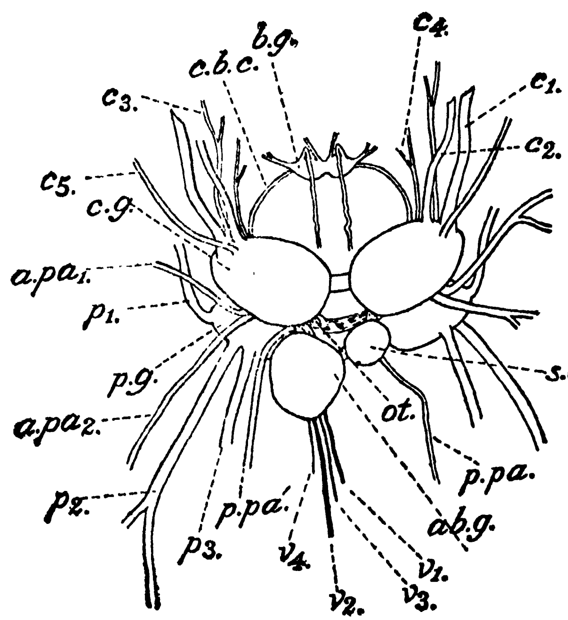
RENAL SYSTEM.

The renal system (Pl. VIII, fig. 8.) consists of a thin-walled renal chamber or the kidney (*r.c.*) which is coelomic in origin like the pericardium (*pe.*). It is situated immediately behind the pericardium and extends almost to the posterior end of the body. From the anterior right corner it gives off a diverticulum (*di.r.*) which, after communicating with the pericardial chamber by means of the reno-pericardial

opening (*r.p.o.*), runs forward on the right side of the pericardium close to the body wall, and turning to the left in front of the pericardium opens out medially on the dorsal body wall by the renal pore (*r.o.*) situated immediately behind the anus. The renal chamber and its diverticulum are lined with small cubical cells with vacuolated cytoplasm and basally placed nuclei. The reno-pericardial opening is without a funnel, and provided with short ciliated cells. The extremely minute renal pore can only be made out in serial sections of the kidney and is lined by a ciliated epithelium which is a continuation of the general epithelium of the body wall.

NERVOUS SYSTEM AND SENSE ORGANS.

Souleyet (**57**) remarked on the nervous system of *Stiliger souleyeti* (syn. *Calliopaea souleyeti*) as follows: " Le system nerveux resemble a cellui des *Tergipes* ; les ganglions qui composent dans des connextions un peu differentes, (fig. 27 et 28) Les yeux ne sont plu aussi en rapport immediant avec les ganglions cerebraux." His diagrams represent the dorsal and the ventral aspects of the brain alone, and indicate the origin of three nerves from the cerebro-pleural ganglion, one from the pedal, two from the abdominal and three from the supra-intestinal.



TEXT FIGURE. 1.—Central nervous system dissected out and highly magnified to show the various ganglia and the origin of nerves.

From his drawings it is, however, clear that the sub-intestinal ganglion is absent, but neither the ganglia nor the nerves are named. Later, Bergh (**9**) and Eliot (**25** and **26**) did not give any account of the nervous system in their descriptions of *Stiliger ;* and thus the nervous system in the genus remains practically unknown.

The animals being extremely small, the investigation of the various ganglia and the numerous delicate nerves in particular was very difficult. Dissections were made under a binocular microscope focussing a strong beam of light from an illuminator on the object. The methods adopted by Russel (**54**) for the investigation of the nervous system of *Elysia viridis* have been followed here with success.

The central nervous system of *Stiliger gopalai* consists of four pairs of oval, pale white ganglia placed immediately behind the pharyngeal bulb forming a ring round the oesophagus. There are a pair of cerebro-pleural ganglia (text fig. 1 and Pl. VIII, fig. 9, *c.g.*), a pair of pedals (*p.g.*), a pair of viscerals (*ab.g.* and *s.i.g.*) and a pair of buccals (*b.g.*). The cerebral and the pleural centres are fused together to form the cerebro-pleural ganglia, which are united above the oesophagus by a short cerebral commissure. The cerebral centres are also joined below the oesophagus by a very delicate connective, the cerebro-buccal commissure (*c.b.c.*), which bears a pair of minute and elliptical buccal ganglia (*b.g.*) lying posteriorly on the pharyngeal bulb. The pleural centres are likewise joined beneath the oesophagus by the visceral loop bearing a pair of visceral ganglia of unequal size. Of these two ganglia, the one to the left, the abdominal (*ab.g.*), is bigger and the other to the right, the supra-intestinal (*s.i.g.*), is comparatively small. The two are joined by a short connective between them. The supra-intestinal is joined to the right pleural centre by a short commissure, and similarly the abdominal to the left pleural centre. The pedal ganglia (*p.g.*), which are of the same size as the cerebro-pleurals, lie posteriorly beneath the cerebro-pleural ganglia and are joined by the pedal commissure lying beneath the oesophagus. The pedals are also connected to the cerebral and the pleural centres by means of the cerebro-pedal and the pleuro-pedal connectives respectively.

Eight pairs of nerves arise from the cerebro-pleural ganglia, of which the first six are cerebral nerves from the cerebral centres and the remaining two are the anterior pallial nerves[1] from the pleural centres. The first pair of cerebral nerves (text. fig. 1 and Pl. VIII, fig. 9, *cl.*), which is comparatively stout, arises from the antero-dorsal region of the cerebro-pleural ganglia and proceeding forward divides at the bases of the rhinophores into several branches to innervate these organs. This pair of nerves does not bear any discrete ganglia either at the proximal or the distal end. The second pair (*c*2.) arising in front of the first pair, reaches the labial folds and supplies them with several minute branches. The third pair (*c*3.) innervates the channel of the mouth and the retractors of the pharyngeal bulb. The fourth pair (*c*4.) is extremely delicate and supplies the pharyngeal bulb itself. The fifth (*c*5.) and the sixth pair of cerebral nerves supply the eyes and otocysts respectively. The optic nerve (*c*5.) bears a small optic ganglion (*op.g.*) as shown in Pl. VIII, fig. 9. The otocyst (text. fig. 1, *ot.*) being sessile, its nerve is extremely short. The anterior pallial nerves (*a.pa.*1 and *a.pa.*2.) arise from the junction of the pleural and the pedal centres. The first of these two pairs proceeds anteriorly and supplies the sides of the neck

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[1] The terminology followed here with reference to the various nerves is essentially that adopted by Russel (**54**).

region, while the second pair turns behind to supply the sides of the animal immediately behind the neck. The first pallial nerve of the right side gives off a short branch (*n.p.*) to supply the penis-pouch and the vas deferens. Owing to the fact that this nerve arises from the junction of the pleural centres and that a few fibres pass from the pedal ganglia into this nerve, the innervation of the penis was believed by some authors to be pedal.

Three pairs of nerves arise from the pedal ganglia(*p*1, *p*2 and *p*3.) to supply the entire length of the foot. The pedal nerves, compared to other nerves, are fairly stout.

Three pairs of very delicate nerves take their origin from the buccal ganglia, of which the first pair (Pl. VIII, fig. 10, *b.n*1.) arises anteriorly from the buccal ganglia and innervates the radular sac. The second pair (*b.n*2.) arising laterally close to the cerebro-buccal connective (*c.b.c.*) supplies the pharyngeal bulb. The nerves forming the third pair (*b.n*3.), known as the gastro-oesophageal nerves, arise directly from the anterior middle region of the buccal ganglia (*b.g.*). There are no gastro-oesophageal ganglia. The gastro-oesophageal nerves (*b.n*3.) proceed hindward remaining in close contact with the oesophagus. Along with the oesophagus and the ducts of the salivary glands they pass through the nerve collar and proceed ventrally on the wall of the stomach ending in a pair of minute ganglia (*g.*). The gastro-oesophageal nerves in the region of the oesophagus and the stomach bear a number of small ganglion cells (*g'*). From all these ganglion cells nerve fibres start and ramify on the surface of these organs. Posteriorly this network joins a similar ramification derived from the gastro-hepatic nerve supply of the abdominal ganglion.

There are only two visceral ganglia, *viz.*, the abdominal and the supra-intestinal ganglia (Pl. VIII, fig. 9, *ab.g.* and *s.i.g.*). As in *Limapontia* the sub-intestinal ganglion is absent since it is fused with the pleural centre of the left side. A single nerve, the posterior pallial (*p.pa.*), arises from the supra-intestinal ganglion and passing beneath the spermatheca reaches the dorso-lateral region of the integument and innervates it. The corresponding nerve of the left side (*p.pá.*) takes its origin from the junction of the pleural and the abdominal centres since the sub-intestinal is absent as already stated. A branch from the main nerve of the supra-intestinal ganglion innervating the pericardium, the aorta and the kidney has been described by Russel (**54**). Owing to the minuteness of this branch I was unfortunately not able to trace it.

Four extremely delicate and ganglionated nerves, the visceral nerves, take their origin from the posterior face of the abdominal ganglion. The first of these nerves (*v*1.) proceeds beneath the oesophagus and reaching the mucous gland ends in a small ganglion (*ge.g.*) from which a ramification of nerve fibres spreads all over the surface of the mucous gland and the vagina forming thus the genital plexus. This nerve, before it ends in the genital plexus, gives a short branch, the right hepato-gastric nerve (*r.h.g.*), which supplies the right side of the stomach and its diverticulum of the same side. The second visceral nerve (*v*2.) from the abdominal ganglion is seen as a thin wavy line passing by the side

of the oesophagus on its left side. It proceeds nearly to the posterior region of the left side of the stomach and forms the gastro-hepatic plexus. The third nerve (*v*3.) passes by the side of the intestine and after giving a short branch (*n.in.*) to that organ proceeds hindward to innervate the aorta, the heart, the pericardium and the renal chamber (*p.c.r.*). The fourth of the visceral nerves (*v*4.), which takes its origin from the lower surface of the abdominal ganglion, innervates the ampulla of the hermaphrodite duct.

The organs of special senses consist of the eyes, the otocysts, the rhinophores and the labial folds. Besides these the dorsal papillae and the whole of the external surface of the animal serve as organs of touch.

A pair of dark minute eyes (*ey.*) lies behind the rhinophores immediately beneath the integument covering the neck region. The optic nerves are long and bear the optic ganglia (*op.g.*). Each eye is enclosed in a thin membranous capsule and shows a black pigmented cup-shaped retina, a round globular lens and a thin transparent cornea. The optic nerve enters the eye from its lower surface and innervates the retinal cup. The otocysts (text. fig. 1, *ot.*) are a pair of minute bodies placed close to the pedal ganglia, but they receive their nerve supply from the cerebro-pleural ganglia. Each otocyst contains a single otolith. These are the earliest sense organs to make their appearance in the course of development and serve as the balancing organs.

The rhinophores are smooth, pointed at their tips, and without the grooves found in *Ercolania*. They are provided with a ciliated epithelium and receive their nerve supply from the first pair of cerebral ganglia. Their function has been believed to be olfactory by some authors [Alder and Hancock (**6**), Hancock and Embleton (**35**), and Eliot (**26**)], but Agersborg (**2**) is of opinion that they respond only to a general chemical stimulus.

The labial folds lie on either side of the mouth as fleshy thickenings. They are provided with vibratile cilia and receive their innervation from the second pair of cerebral nerves. They are supposed to be the seat of the sense of taste.

REPRODUCTIVE SYSTEM.

The organs of reproduction of *Stiliger* were first studied by Souleyet (**57**) and later on by Bergh (**9**). As the complicated ducts and their glandular annexes are imperfectly understood, I propose to describe them in this species in somewhat greater detail. The general arrangement of the ducts and the position of the glands are very much as in *Limapontia nigra* described and figured by Alder and Hancock (**5**).

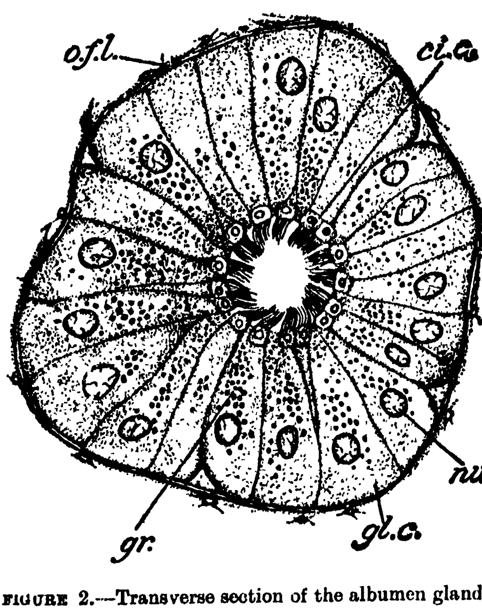
In *S. gopalai* the reproductive organs (Pl. VIII, fig. 11 and Pl. IX, fig. 1) occupy by far the largest space in the peri-visceral cavity and consist of numerous follicles of the hermaphrodite gland, the hermaphrodite duct and the anterior genital complex. The follicles of the hermaphrodite gland (Pl. VIII, fig. 11, *hr.gl.*) are reniform and small in size, each measuring about 0·6 mm. along its long axis. Most of them lie close to the integument, and in life the yolk-laden eggs give

a pale yellow colour to them. As in all Ascoglossa described by Pelseneer (46) and Eliot (26), each follicle produces spermatazoa as well as ova. Sections of the animal fixed in Brasil's modification of Bouin's fluid and stained with iron haematoxylin and eosin show the follicles clearly. Each of the follicles has a thin germinal epithelium close to which lie a number of spermatocytes and oocytes of all stages of growth. Besides these, there are always well developed sperms and eggs. Each ovum is filled with granules of yolk, and has a fairly large nucleus and a nucleolus. The sperms are found in clusters and each possesses a sinuous head (which is deeply stained by haematoxylin) and a long tail (stained red by eosin). The follicles have the same histological structure, but for convenience of description may be divided into (i) an anterior group placed in front of the left hepatic diverticulum and to the left of the oesophagus; and (ii) a comparatively large posterior group occupying almost the entire posterior half of the body behind the hepatic diverticula. The thin, minute, transparent ductules (Pl. VIII, fig. 11, *du.*) arising from the follicles (*hr.gl.*) of each group form a small duct. The duct from the anterior group (*hr.d*1.) passes beneath the hepatic diverticulum and meets its fellow (*hr.d*2.) from the posterior group about the middle region of the body to form a common hermaphrodite duct (*hr.d.*). The hermaphrodite duct is very narrow and thin at its origin but has an abrupt, opaque, whitish dilatation in its course called the ampulla (*hr.am.*) about 2·5 mm. long and 0·5 mm. thick. After passing forwards beneath the stomach and the oesophagus it turns to the right becoming narrow again on reaching the anterior genital complex.

The anterior genital complex (Pl. VIII, fig. 11 and Pl. IX, fig. 1) is placed to the right side of the oesophagus and the stomach, and is disproportionately large in relation to the size of the animal. It consists of the male genital organs (*pen.*, *pen.s.*, *pr.d.*), the oviducal organs (*al.gl.* and *mu.gl.*) and the apparatus consisting of the vagina (*va.a.*), the vaginal canal (*va.c.*) and the spermatheca (*spt.*) for receiving and storing sperms during coitus. In order to show the narrow part of the hermaphrodite duct and its communication with the male genital and oviducal organs, it is essential to remove the entire spermatheca (with its outline shown in dotted lines in Pl. IX, fig. 1). The downward loop of the mucous gland is slightly twisted to the right so that the bulged part of the vaginal canal (*va.d.*) and the duct of the prostate (*pr.d.*), which lie normally ventral to the anterior region of the mucous gland (*mu.gl.*), come in direct view, with the short communication between them clearly seen.

The narrow terminal region of the hermaphrodite duct communicates anteriorly with the vas deferens (Pl. IX, fig. 1, *v.d.*) and ventrolaterally with the oviducal organs (*al.gl.* and *mu.gl.*). The vas deferens is an extremely narrow and short duct which swerves round the penis pouch (*pen.s.*). The latter lodges the penis, which, in a retracted condition lies inverted and in expanded condition becomes everted and pushed out through the male genital opening situated on the right side of the neck immediately behind the eye. It then assumes a conical form bearing at its tip a minute recurved crystalline stylet (Pl. IX, fig. 2).

The vas deferens is continued through the penis and opens out to the exterior by a small perforation present at the tip of the stylet. A duct (Pl. IX, fig. 1, *pr.d.*) from the prostate gland joins the vas deferens at the point where the latter communicates with the hermaphrodite duct. It runs backwards communicating with the vaginal canal, and at a point where the stomach receives the hepatic diverticula, it divides into two branches. Following the course of the hepatic diverticula the branches reach the body wall on either side, each dividing into two slender ducts (Pl. VIII, fig. 11, *pr.d*1. and *pr.d*2.). One proceeds anteriorly and the other posteriorly parallel to the caecal prolongations of the digestive system, communicating with the glandular ramifications of the prostate gland (*pr.r.*) in the cerata. The branch running anteriorly along the right side of the animal is much shorter than its fellow on the left and is supplemented by another branch that joins the main duct directly. In life the ramifications of the prostate are slender and pale white in contrast to the stout and grayish-green ramifications of the digestive gland found in the cerata. In transverse sections of the cerata the slender branches of the prostate are seen close to the outer wall with the granular contents of their cells stained deeply with eosin ; whereas the digestive gland occupies the central space with the granules of its cells stained densely with haematoxylin.



TEXT FIGURE 2.—Transverse section of the albumen gland. ×600.

A small translucent albumen gland (Pl. IX, fig. 1, *al.gl.*) and a large transparent mucous gland (*mu.gl.*) belong to the oviducal organs. The albumen gland lies ventral to all other parts of the anterior genital complex and is paired being divisible into two rami, each about 1·75 mm. long. The length of the gland varies with the numbers of eggs passing into it. In preserved specimens its surface is much lobed. There is a single short duct arising from the gland, which, along with the mucous gland communicates with the terminal region of the hermaphrodite

duct as already stated. The albumen gland of *Stiliger* corresponds to the opaque and greatly coiled albuminous part of the muco-albumen gland of the Nudibranchs in general, but here it is much more simple. The gland is tubular in section (text fig. 2.) and has a thin outer layer (*o.f.l.*) of fibrous tissue with a few strands of muscles and a comparatively thick inner layer formed of groups of large glandular cells (*gl.c.*) alternating with small ciliated interstitial cells (*ci.c.*). The cytoplasm of the glandular cells reveals large granules (*gr.*) staining deeply with haematoxylin. There are indications that this gland provides the albumen that surrounds the egg and also the outer capsule. The mucous gland (Pl. IX, fig. 1, *mu.gl.*) is about 3·5 mm. long and 2·5 mm. wide and lies along the right side of the body. In dissecting specimens preserved in formalin the gland swells up on contact with water, frays out and loses its shape. Specimens preserved in alcohol are for this season preferred. The mucous gland is a simple wide roughly U-shaped tube lined with tall columnar glandular ciliated cells (Pl. IX, fig. 3) and opens out to the exterior by the oviducal opening (fig. 1, *op.ov.*) situated immediately behind the male genital opening. The nuclei (*nu.*) of the gland cells are basal, and the cells which stain deeply with eosin contain very little cytoplasm (*cy.*). The slimy transparent secretion of this gland exudes with the eggs at the time of oviposition through the oviducal opening.

The vagina (*va.a.*), its passage and the spermatheca (*spt.*) constitute the apparatus for receiving the sperms during copulation. These are collectively termed 'the androgynous organs' by some authors [Alder and Hancock (**5**)]. In tracing back these organs from the vaginal opening (*op.va.*), we find that the latter leads into a small tubular passage, which at once dilates into what is called the ampulla of the vagina (*va.a.*) which is about 0·2 mm. long. The narrowed vaginal passage (*va.c.*) runs at a right angle to the ampulla on the surface of the mucous gland, and proceeds parallel to the main duct of the prostate (*pr.d.*) which is continued as a small dilatation (*va.d.*) at the anterior region of the mucous gland. In figure 1, this dilatation communicates on the right with the duct of the prostate (*pr.d.*), on the left with a short duct leading to the spermatheca (*spt.*) and ventrally with the oviducal organs (*al.gl.* and *mu.gl.*). The ampulla of the vagina and its long narrow passage are lined internally by a layer of low ciliated cells. The dilatation of the vaginal passage close to the mucous gland is likewise ciliated, but the cells lining it are peculiar in that they resemble the cells of the mucous gland, though they are much shorter in length. The spermatheca is large and spherical having a diameter of about 2·25 mm. It is situated behind the pharyngeal bulb and rests partly on the oesophagus and partly on the mucous gland. When full, its contents impart a brown colouration to it. It has an outer fibrous layer, and an inner glandular layer, the cells of which do not bear any cilia. The duct of the spermatheca is extremely short and arises ventrally on its right. Sections of the animal show spermatozoa in the vaginal ampulla, in the dilation of the vaginal passage and in the spermatheca.

Souleyet and Alder and Hancock mistook the hermaphrodite gland in many of the Elysioid forms for the ovarium and the prostate for the

testis. Souleyet (57) was apparently not fully aware of the significance of the albumin gland and associated it with the male genitalia. This gland has been represented by Bergh (9) in *S. bellulus* as an unpaired structure ; but in *S. gopalai* it is paired as in *S. souleyeti*. In *S. bellulus* the penial stylet is slender and as long as the penis itself ; in *S. pica* [Annandale and Prashad (56)] it is extremely short, slender and minute ; in *S. gopalai* it is short, recurved and has the same shape as that of *Limapontia capitata* (Bergh 9, Taf. 26, fig. 21.).

BREEDING AND SPAWNING HABITS.

Animals kept in captivity in brackish water amidst algae in glass dishes were often observed to copulate. The details may be observed with a hand lens. When two individuals approaching in opposite directions come in contact with each other their short, conical penis is usually exserted. Their right neck regions are brought close together, and as soon as the penis of one individual is thrust into the vaginal passage of the other, the animals come closer and curve in the manner shown in (Pl. VII, fig. 6). Muscular spasms pass over them as they lie curled up. The copulation does not last more than three minutes, after which the individuals separate. As a rule they do not feed until the spawn is deposited. But some animals have been observed to copulate more than once before spawning. A few hours after spawning their normal movements are resumed until the next stimulus of contact prepares them for copulation.

During copulation the sperms from the terminal region of the hermaphrodite duct find their way into the vas deferens. The duct of the prostate brings directly into the vas deferens a slimy secretion, together with which the sperms of each individual are conducted through the penis into the vaginal pasage of the other. The sperms thus received in the vaginal passage find their way into the spermatheca where they remain for some time. As the eggs pass from the hermaphrodite duct into the oviducal organs, the sperms from the spermatheca enter into the dilatation of the vaginal canal and from there into the oviduct. The eggs are then fertilized and are immediately directed into the albumen gland, where they receive a coating of albumen and are enclosed in small capsules. They next pass through the mucous gland to the exterior along with its secretion.

Copulation does not seem to be absolutely necessary for the production of fertile ova. Animals kept separately for about a fortnight in confinement produced perfectly healthy and fertile ova, but they were observed to deposit fewer strings of spawn at longer intervals. This was apparently a case of self-fertilisation. As the animals under laboratory conditions spawn an hour or two after receiving the sperms of other individuals, it is presumed that in separated individuals the sperms have not already been received and stored in some part of the reproductive system. If it is remembered that the dilated part of the vaginal passage communicates with the duct of the prostate (*vide* Pl. IX, fig. 2.), the passage of the sperms from the vas deferens into the region of the prostate duct and thence through the vaginal passage

and the short connecting canal into the oviducal organs to fertilize the eggs is readily explained.

The spawn is usually attached to a clean thread of alga, but in captivity it is also deposited on the surface of the glass dish or of water. In spawning as observed under the binocular microscope, the oviducal opening becomes widened and the animal bends slightly to the right bringing the pressure of the blood to bear upon the anterior genitalia by a slight contraction of the posterior region of the body. The albumen gland is extended to twice its normal length and gets filled with eggs, which, provided with small enclosing capsules, pass to the mucous gland and thence to the exterior through the oviducal opening. As the eggs pass out they are arranged in a regular closed anti-clockwise spiral. The transparent and sticky secretion of the mucous gland covers the spiral egg-mass completely, giving it the appearance of a string and keeping the eggs in position. The secretion becoming slightly hardened in contact with water, also serves to fix the strings of spawn to the algae or to any other surface upon which they are deposited. While the spawn is being deposited on an algal thread the animal moves forward twisting it round. On a plane surface, however, it assumes the form of a crescent. When the spawn is deposited on the surface of water, the animal floats in the usual manner with its ventral side upwards, so that the eggs come to lie beneath the surface of water suspended by the secretion of the mucous gland. Each string of spawn (Pl. IX, fig. 4.) when stretched is 10 to 25 mm. long, 1·25 mm. thick and contains 700 to 1,500 minute eggs. Two individuals left together in water for a couple of days produce nearly a dozen such strings of spawn. As a result of repeated spawning the individuals are much reduced in size. The length of the string and the number of eggs in it vary with the external environmental conditions. It has been observed that while healthy individuals under favourable conditions deposit long strings of spawn with large number of eggs, those that are starved or exhausted deposit only short strings with fewer eggs.

NOTES ON DEVELOPMENT.

Of the various workers who studied the development of Opisthobranchs, Casteel (16) gave a detailed account of the cell-lineage and early development of the egg into a veliger in the Nudibranch, *Fiona marina.* In this paper I have attempted to describe the more important stages in the early development of *S. gopalai.* The egg (Pl. IX, fig. 5) is a pale yellow spherical body with a diameter of 70μ surrounded by an albuminous, viscous substance, and is enclosed in a thin, roomy, transparent capsule consisting of two laminae. The capsule is slightly oval, about 175μ long, but becomes rounded as the egg divides. Occasionally a capsule of unusually large size with two or three eggs is met with. Only one egg, however, grows into a larva at the expense of the others. The egg has an extremely delicate vitelline membrane and finely divided yolk globules distributed almost uniformly throughout the egg. Immediately after spawning, one or two minute polar bodies are seen loosely attached to the egg near the apical region.

Two hours after spawning, the first cleavage appears, dividing the egg into two almost equal cells, which are rounded at first, but later flattened at the point of cleavage as they press each other (fig. 6). The second cleavage appears two hours after the first at right angles to the latter resulting in four cells of equal size (fig. 7). At about the end of five hours after spawning, the four blastomeres divide giving rise to an upper group of four micromeres and a lower group of four megameres (fig. 8). Further cleavages are rapid with the result that about twenty hours after spawning the egg has divided into a mass of minute cells.

At the end of about twenty four hours after spawning, invagination followed by the formation of the blastopore begins in the central region of the mass of cells at the vegetative pole, (Pl. IX, figs. 9 and 10) resulting in a gastrula. When the invagination is complete, the gastrula has the appearance of an inverted cup with its longitudinal axis shorter than its transverse axis, and its apical region slightly flattened. Soon the gastrula becomes elongated with its apical region prominently pointed (fig. 11). Increased division of the cells near the blastopore causes the region surrounding it to become broader while the blastopore itself is narrowed gradually until it is reduced to a minute crescentic slit (fig. 12), which is probably finally closed[1].

At a later stage which it reaches in about forty five hours (Pl. IX, fig. 13), the gastrula is so far advanced as to pass on to an early veliger larva. In the region of the crescent of the blastopore the stomodaeum (*sto.*) is formed as a deep invagination of the ectoderm. Immediately above this region the velar lobes (*ve.*) make their appearance as two rounded lobes, one on either side, with minutely ciliated margins with the help of which the early veliger rotates inside the capsule. Ventral to the stomodaeum the foot (*ft.*) is formed as a broad median protuberance. The posterior region of this early veliger reveals a broad layer of glandular cells which secrete a thin, transparent shell (*sh.*). The preceding stages, however, show that the shell gland begins as an ectodermal invagination, which opens and extends over the posterior region followed by the thickening of its cells. In the early veliger stage the enteron appears below the shell gland. The anterior end of the enteron touches the stomodaeal invagination (*sto.*) but does not communicate with it. The region immediately behind this is slightly saccular and forms the stomach (*st.*). The liver appears in the form of two lobes of unequal size (fig. 13, *l.l.* and *r.l.*), the left being considerably larger than the right. The intestine (*int.*) is a narrow posterior prolongation of the stomach and joins the ectoderm near the base of the foot. Above the level of the intestine lies a group of vacuolated cells forming the larval kidney (*k.*). The otocysts (*ot.*) which are the earliest sense organs to appear in the larva are seen, one on either side, at the base of the foot below the ectoderm.

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[1] As the cells are opaque in this region and as no sections of the gastrula have been taken, I cannot say with certainty that the blastopore closes completely after it is reduced to a minute slit. In *Fiona marina* and other Opisthobranchs the blastopore has been observed by several authors to close completely and in *S. gopalai*, which is an allied form, the same phenomenon may occur.

A typical veliger is formed before the completion of sixty five hours after spawning. During this period the velar lobes increase enormously in size followed by a thickening of their free edge with bigger cilia. The constriction between the two lobes of the velum grows deeper. The stomodaeum finally opens into the stomach where it communicates with the larger left liver lobe. The intestine gets elongated and slender and opens to the exterior. The shell gland thins out as it grows in extent, as a consequence of which the shell grows in size. The foot, which is merely a median protuberance beneath the stomodaeal region, now gradually becomes broadened and flattened. Its upper surface comes to possess minute cilia, while the cells lining its under surface secrete the operculum. The strongly pigmented larval kidney lies immediately above the terminal region of the intestine. At the end of sixty five hours the veliger is fully formed in its egg-capsule with its various organs still slightly opaque, and is seen to rotate inside with the help of its powerful velar cilia which strike against the wall of the enclosing capsule. By about the end of ninety hours or early on the fifth day after oviposition, the thinned-out enveloping membrane is ruptured liberating the larva. The sticky substance, which surrounds the eggs and keeps them in position, becomes soft enough to allow the larvae to escape into the surrounding water. All the larvae in a string of spawn do not escape simultaneously, some taking a longer time than the others.

The larva is a typical free swimming veliger, 120μ long and 85μ broad, (Pl. IX, figs. 14 and 15) with a transparent nautiloid shell (*sh.*) and an operculum (*op.*). The antero-dorsally situated velum (*ve.*), is much constricted in the middle region, dividing it into two large lobes with their upper surface hollow. The margins of the velar lobes bear big locomotive cilia and are continuous with those of the narrow constricted middle region. Lower down the velum lies the broad, flattened ciliated foot (*ft.*), which bears on its ventral side an operculum (*op.*). The dorsal retractor muscles (*d.r.*) runs forwards from the left posterior side of the larva behind the large liver lobe to about the middle region of the stomach, where it divides into two strands, which terminate in the antero-dorsal region of the larva. By the contraction of this muscle the velum is withdrawn into the shell. The retraction of the foot is caused by the right and the left retractor muscles of the foot (*r.f.*), which start from the dorsal middle region of the posterior half of the larva and turning along the sides pass anteriorly to terminate in the foot. The mouth lies between the velum and the foot and leads into a fairly long ciliated passage, the stomodaeum (*sto.*), the posterior end of which communicates with a large saccular stomach (*st.*). The latter bears a large liver lobe on the left side and a similar but a smaller one on the right. The intestine (*int.*), starting from the middle region of the stomach, passes forwards to open at the anus situated on the right side slightly below the level of the margin of the shell. The stomach and the intestine are internally ciliated like the stomodaeum. Green unicellular algal matter, which the animal has taken in, is seen in the stomach revolving with great rapidity by the action of cilia. The larva has a pair of large otocysts (*ot.*) placed at the base of the foot, one on either side. The

eyes are absent in the just hatched larva, but four or five days later they make their appearance as two dark spots at the base of the velar lobes.

Our knowledge of the metamorphosis of the larvae of Opisthobranchs is inadequate. Nordman (**41**) and Schultze[1] have described briefly some aspects of the post-larval development of *Tergipes edwardsii* and *Tergipes lacinulatus* respectively. In spite of all precautions, Infusorians, which grew under laboratory conditions in dishes and attacked the larvae, could not be kept under check. The larvae that escaped the attack of Infusorians for a fortnight grew only in size.

Two or three days after a heavy shower in the first week of October and in the last week of December 1935, metamorphosed young ones in various stages of growth, exceeding 1·25 mm. in length, were obtained from the brackish water pools near the mouth of the river Cooum. In structure they did not differ much from the adults, but the gray and yellow colour of the integument characteristic of the adults was not developed. The young ones were all bright green owing to the presence of algal matter in the gut and the hepatic caeca, and without shell or operculum. The velum had completely disappeared, but the large cilia in the anterior region of the animal (Pl. IX, fig. 16) were still present. The rhinophores of the young ones had blunt tips in contrast to the pointed ones of the adult. The eye posterior to the base of each rhinophore was disproportionately large in relation to the size of the animal. The otocysts near the cerebral ganglia, were seen conspicuously through the transparent integument. The anterior cleft of the foot was not prominent, but the foot was extended into a tail like filament. The only two pairs of cerata were in the form of small protuberances, with the hepatic caeca extending into them. Under the binocular microscope the cerata were of a purple shade in colour, which, however, faded as more were formed. At the stage when five or six cerata were formed on either side, the gray pigment gradually appeared. In the laboratory, the young ones fed voraciously on *Chaetomorpha* and grew rapidly in size. Young forms, only 1·25 mm. in length, attained the full size of the adult within a period of twelve days, and began depositing spawn from the fifteenth or the sixteenth day.

Some points of interest in the breeding habits, early development and growth of *S. gopalai* need special mention here.

That there is no definite period of breeding is clear from the fact that sexually mature individuals were obtained throughout the year either from the Adyar or from the Cooum brackish water pools. Semper (**55**) and Orton (**45**) believed that in the tropics, where the temperature is high and remains constant or almost constant, most of the animals breed throughout the year. Aiyar[2] and Subramaniam[3] have observed continuous breeding in Madras in *Salmacis bicolor* and *Clibanarius olivaceus*.

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[1] *Weigm. Arch.* 1849, i. p. 277, as referred by Eliot (**26**).
[2] *Proc. Ind. Acad. Sci.*, I, p. 726 (1935).
[3] *Journ. Royal Micr. Soc.*, LV, p. 14, (1935).

It has been observed by various writers that when the temperature is high the development of early larvae is accelerated. In *S. gopalai* the veligers escaped out of the spawn within a period of not more than five days after oviposition, whereas in allied Opisthobranchs of the British coasts the minimum time taken was not less than a fortnight (*vide* Reid, **53** and Eliot, **26**). Such a rapid development in this form is due probably to high temperature conditions which prevail in Madras.

In *S. gopalai* the young ones grow rapidly to adult size and attain maturity within a fortnight. Orton (**44**) recorded a similar phenomenon in the life-history of *Galvina picta*. A raft moored about six weeks after it was in the sea showed a number of Nudibranchs, particularly *Galvina picta* of varying sizes and their egg masses among a thick growth of *Obelia geniculata*, on which those animals were observed to feed. He observed that "the Nudibranchs had undoubtedly peopled the raft as veligers, rushed through their development at the expense of the Hydroids and were giving off veligers again to populate Hydroids elsewhere within a period of not longer than six weeks and two days". In *S. gopalai* the growth of the young ones is more rapid than in the case of *Galvina picta*. In the brackish waters of Madras where the environmental conditions are continually changing, an extremely rapid growth to attain maturity seems to be a necessity, as favourable conditions do not last long.

Behaviour of the Animal in Respect of Variations in Salinity.

Apart from other factors such as temperature and food supply, the salinity of the brackish water, which has been observed to be always changing, seems to exercise a great control over the animals. When the animals were first observed in the brackish water pools near the mouth of the Cooum about the end of August 1935 and in the backwaters of Adyar in the month of September, the waters in both the places had a low salinity as the localities were not in open communication with the sea and were flooded by freshets brought by the rivers. The bar near the mouth of the river Cooum opened during the last week of September 1935, much earlier than the one at the Adyar river mouth. As more and more sea water was brought into the brackish water pools, the salinity increased and the algae disappeared, the animals were no longer found. In the Adyar backwaters, however, the salinity remained low, and individuals of *S. gopalai* were still found. By about the middle of October 1935, the salinity in the pools at the mouth of the Cooum had been brought down by rainfall. Three days after the rain numerous young ones ranging from 1·25 mm. to 2·5 mm. in length appeared suddenly. But the low salinity condition was not maintained long with the opening of the bar. With the gradual rise in the salinity the animals began to diminish in numbers until they grew scarce. Up to the month of November 1935, adult animals were collected in Adyar, but none after the bar had been opened. The bar near the mouth of the river Cooum silted up very early; and during the last week of December 1935, a few days after rains, metamorphosed young ones appeared again with the sudden fall in the salinity. The appearance of the young forms coincided with the growth of *Chaetomorpha* (on which they feed)

on the sides of rocks and other hard surfaces. From the last week of December 1935, and as long as the bar remained closed near the mouth of the Cooum, the animals continued to occur.

The observations made seem to show that the animals live in water of salinity distinctly lower than that of the sea. Since they are rare when the bar remains open for considerable periods, I am led to believe that, due to the incoming sea water and the increase in salinity a large number perishes. When more fresh water accumulates in the brackish water pools reducing the salinity, the animals occur in large numbers and breed. As the metamorphosed young ones were obtained nearly always after a heavy shower, it seems probable that a lowered salinity is an essential condition for metamorphosis.

SYSTEMATIC POSITION OF *S. GOPALAI*.

The Sub-Order Ascoglossa, of the Order Opisthobranchiata, is characterised by the presence of a suctorial pharynx, of a uniseriate radula the teeth of which when worn out are retained in a sac or ascus, of a single otolith in each otocyst, of a penial spine, and of a visceral loop with two or three visceral ganglia. There are no jaws.

The family Hermaeidae of Ascoglossa includes *Stiliger*, *Ercolania*, *Hermaea* and *Alderia*. O'Donoghue (**43**) is of opinion that the family should be named Stiligeridae and not Hermaeidae, for the reason that *Stiliger* and not *Hermaea* is the oldest member of the family. According to strict rules of biological nomenclature he is correct, though the family is better known by the name Hermaeidae.

The general Eolidiform appearance of the body, the position of the anus in front of the pericardium and the presence of a single pair of long and smooth tentacles place the present form in the genus *Stiliger* of Ehrenberg.

The specific characters of *Stiliger gopalai*, sp. nov. may be summarized as follows : colouration of the body is deep brownish gray stippled with yellow ; cerata, about forty on each side coloured dark gray with white tips, are neither very slender nor bulged out ; the ramifications of the digestive gland in the cerata have a single main stem with a few minute branches ; foot is narrow, pale yellow, with the anterior lobes rounded and the tail filamentous ; the radula has five teeth in the ascending axis and seven in the descending axis ; axes are straight but not spiral ; margin of the teeth is wavy ; penial armature is short and recurved ; there is no pericardial prominence.

Stiliger gopalai differs from all other species described hitherto but combines in itself several characteristics of different species of the genus. The present form differs from *Stiliger bellulus* (syn. *S. mariae* **22** ; **26** : and **9**, 1872) in the nature of the radula, cerata and penial armature. In *S. bellulus* the descending axis of the radula is a spiral showing a large number of teeth which have broad bases and narrow apices ; the cerata are conspicuously bulged showing a large number of hepatic ramifications ; and the penial armature is long and slender. In *S. souleyeti* (**57**) the presence of a uniform green colouration, of large and club-shaped cerata and of a radula resembling that of *S. bellulus*, clearly separate it out

from the present species. The teeth of *S. gopalai* resemble very closely those of *S. varians* (**21**); but the marine habitat, the extremely small size of the body, the inflated cerata and the bladder-like pericardial prominence in the latter make it distinct from the former. *S. irregularis* (**21**) is marine, the general colouration is reddish gray, the oral veil is not notched and the margins of the teeth are less wavy than those of *S. varians*. These important features of *S. irregularis* distinguish it from the present form. The presence of a spirally coiled descending axis of the radula, a very prominent posterior prolongation of the pericardium and the probable absence of the penial armature in *S. felinus* (**25**) distinguish it from *S. gopalai*. *S. tentaculatus* (**29**) differs from all others of the genus in having well developed oral tentacles and tentacular prolongations of the foot. The absence of filamentous tail and of white spots in the foot, and the presence of a radula resembling that of *S. bellulus* and of the very slender cerata in *S. pica* (**56**) differentiate it from *S. gopalai*. *S. gopalai* and *S. pica*, however, agree in their brackish water habitat and short penial armature.

In Eliot's opinion *Stiliger ornatus* Ehrenberg, the specific characters of which are not given, agrees with *S. bellulus*. *Pterochilus viridis* of Kelaart (**38**) was, however, doubtfully referred as '*Stiliger? viridis*' by Eliot in 1906 (**23**); but the green colouration of the body and the capsular spawn distinguish it from the present species. The nature of the radula in *S. ornatus* and '*Stiliger? viridis*' is not known. *Custiphorus vesiculosus* of Deshayes was ascribed by Fischer (**32**) to the genus *Calliopaea* while in 1928 O'Donoghue (**43**) referred it to *Stiliger*. Apart from other characters, the colouration of *S. vesiculosus* and the presence of vesicles or globules in the cerata distinguish it from *S. gopalai*. Doubting the correctness of treating *Ercolania* as a genus separate from *Stiliger*, O'Donoghue (**43**) provisionally included under the genus *Stiliger* all the species of *Ercolania*, viz., *E. siottii*, *E. panceri*, *E. uzilli*, etc. As discussed in the history of this genus at the beginning of this paper (*antea* pp. 436-438) *Ercolania* can be distinguished as a separate genus from *Stiliger* on account of the absence of canaliculated grooves in the rhinophores of the latter.

SUMMARY.

1. The external and internal morphology of *Stiliger gopalai*, sp. nov. from the brackish waters of Madras is fully described with a brief account of the bionomics and early development.
2. The digestive system of *S. gopalai* while agreeing with that of several species of the genus, differs from that of *S. souleyeti* in having no oesophageal caecum. The radula closely resembles that of *S. varians* and *Ercolania siottii*. The hepatic ramifications are simple and give off very minute branches.
3. The central nervous system shows a primitive condition as in all Ascoglossa. The visceral loop bears only two ganglia, the abdominal and the supra-intestinal. The sub-intestinal ganglion is absent as in *Limapontia*. Gastro-oesophageal ganglia are absent.

4. The reproductive system is fully described including the histology of the accessory glands. The penial armature is extremely short unlike that of *S. bellulus* and closely resembles that of *Limapontia.*
5. The process of copulation and spawning has been observed. The course of the eggs from the hermaphrodite follicles to the exterior is described. The spawn is a cylindrical string and the eggs are closely arranged in anti-clockwise spiral within. Animals were observed to deposit spawn even without copulation. The animals breed throughout the year.
6. The eggs develop into veligers very rapidly. The metamorphosed young ones, collected from the natural habitat, attain the adult size and maturity within a period of fifteen days.
7. The animals become scarce with the increase in salinity in the brackish waters due to communication with the sea. Large numbers of animals were collected when the salinity was low. A sudden fall in the salinity seems to favour matamorphosis.

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KEY TO LETTERING

ab. g. . . . abdominal ganglion.
al. gl. . . . albumen gland of the anterior genitalia.
an. . . . . anus.
a. pa 1. . . . 1st anterior pallial nerve.
a. pa 2. . . . 2nd anterior pallial nerve.
as. . . . . ascus.
au. . . . . auricle.
b. g. . . . . buccal ganglia.
b. gl. . . . . large buccal glands.
b. gl'. . . . small buccal glands.
b. n 1. . . . 1st pair of nerves from buccal ganglia.
b. n 2. . . . 2nd pair of nerves from buccal ganglia.
b. n 3. . . . gastro-oesophageal nerves.
c 1. . . . . 1st pair of cerebral nerves.
c 2. . . . . 2nd pair of cerebral nerves.

c 3. . . .	3rd pair of cerebral nerves.
c 4. . . .	4th pair of cerebral nerves.
c 5. . . .	5th pair of cerebral nerves.
ca. . . .	caecal prolongations of the digestive system.
c. b. c. . .	cerebro-buccal commussure.
c. g. . . .	cerebro-buccal ganglia.
ci. . . .	cilia.
ci. c. . . .	ciliated cells.
c. n. s. . .	central nervous system.
cr. . . .	crypts through which the glands open.
ct. c. . . .	connective tissue.
cy. . . .	cytoplasm of gland cells.
d. gl. r. . .	glandular ramifications of digestive gland.
di. . . .	diverticulum communicating with the stomach.
di. r. . . .	diverticulum of the renal chamber.
d. r. . . .	dorsal retractor muscle of the veliger.
du. . . .	ductules from the follicles of hermaphrodite gland.
epi. . . .	epithelium.
ey. . . .	eye.
ft. . . .	foot.
g. and g'. . .	small ganglia of the gastro-oeseophageal nerves.
ge. g. . . .	a small ganglion of the first visceral nerve situated in the anterior genitalia.
gl. c. . . .	gland cells.
gr. . . .	granules.
hr. am. . .	ampulla of the hermaphrodite duct.
hr. d. . .	common hermaphrodite duct.
hr. d 1. . .	hermaphrodite duct from the anterior group of follicles.
hr. d 2. . .	hermaphrodite duct from the posterior group of follicles.
hr. gl.. . .	follicles of hermaphrodite gland.
int. . . .	intestine.
k. . . .	kidney of the veliger.
l. . . .	central lumen.
la. . . .	labial folds.
l. l. . . .	left lobe of the liver in the larva.
l. ph. . . .	lumen of anteriormost region of pharyngeal bulb cut in section.
m. . . .	mouth.
m. f. . . .	muscle fibres.
m. g. . . .	unicellular mucous glands of foot.
m. m. g. . .	multicellular mucous glands of foot.
mu. gl. . .	mucous gland of the anterior genitalia.
n. in. . .	a branch of the third visceral nerve to intestine.
n. p. . . .	a short branch from the first pallial nerve to penis pouch.
nu. . . .	nuclei of the gland cells.
oe. . . .	oesophagus.
o. f. l. . .	outer fibrous layer.

o. gl.	odoriferous glands.
op.	operculum of veliger.
op. g.	optic ganglion.
op. ov.	oviducal opening.
op. pen.	opening of the male genital organ.
op. va.	vaginal opening.
ot.	otocyst.
p 1.	1st pedal nerve.
p 2.	2nd pedal nerve.
p 3.	3rd pedal nerve.
p. c. r.	branch of 3rd visceral nerve to the pericardium, heart and renal chamber.
pe.	pericardium.
pen.	penis.
pen. s.	penis pouch.
p. g.	pedal ganglion.
ph.	pharyngeal bulb.
p. pa.	posterior pallial nerve of the right side.
p. pa'.	posterior pallial nerve of the left side.
pr. d.	main duct of the prostate.
pr. d 1.	anterior lateral branch of the prostate.
pr. d 2.	posterior lateral branch of the prostate.
pr. r.	glandular ramifications of the prostate.
r. c.	renal chamber.
r. f.	retractor muscles of the foot of the Veliger.
r. h. g.	right hepato-gastric nerve.
r. l.	right lobe of liver in larva.
r. o.	renal pore.
r. p. o.	reno-pericardial opening.
s. gl.	salivary glands.
sh.	shell of the larva.
s. i. g.	supra-intestinal ganglion.
spt.	spermatheca.
st.	stomach.
sto.	stomodaeum of the larva.
v.	ventricle.
v 1.	1st visceral nerve.
v 2.	2nd visceral nerve.
v 3.	3rd visceral nerve.
v 4.	4th visceral nerve.
va.	vacuoles in the cytoplasm.
va. a.	ampulla of the vagina.
va. c.	vaginal passage.
va. d.	dilated bulb of the vaginal passage.
v. d.	vas deferens.
ve.	velum of the veliger larva.
vei.	veins.

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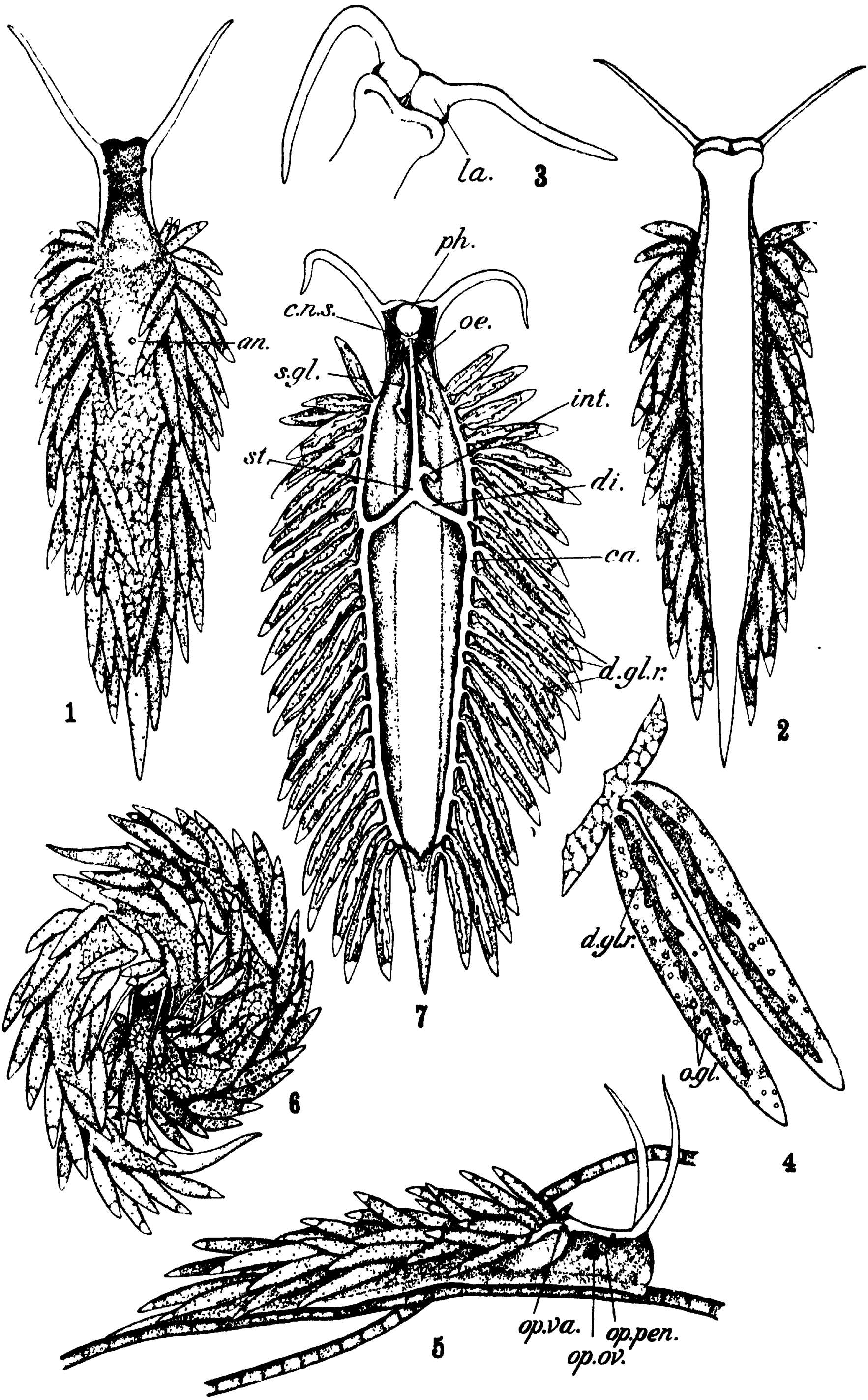
EXPLANATION OF PLATE VII.

FIG. 1.—Dorsal view of *Stiliger gopalai*, sp. nov. ×8.
FIG. 2.—Ventral view of *Stiliger gopalai*. ×8.
FIG. 3.—Ventral view of the snout. ×16.
FIG. 4.—Cerata magnified to show the ramifications of the digestive gland and the odoriferous glands.
FIG. 5.—Side view of *Stiliger gopalai* creeping on *Chaetomorpha*. ×8.
FIG. 6.—A pair of individuals seen in copulation.
FIG. 7.—Digestive system of *Stiliger gopalai* as seen in a dissection made with the aid of the binocular microscope.



Stiliger gopalai, sp. nov.

Photo.-Litho. Office, Survey of India

EXPLANATION OF PLATE VIII.

FIG. 1.—Transverse section of the foot. $\times 600$.

FIG. 2.—A transverse section passing through the mouth region showing the buccal glands. $\times 100$.

FIG. 3.—Side view of pharyngeal bulb with the salivary glands and the buccal glands. $\times 30$.

FIG. 4.—The radula. $\times 100$.

FIG. 5.—A single tooth magnified twice as in Fig. 4.

FIG. 6.—Transverse section of salivary gland. $\times 300$.

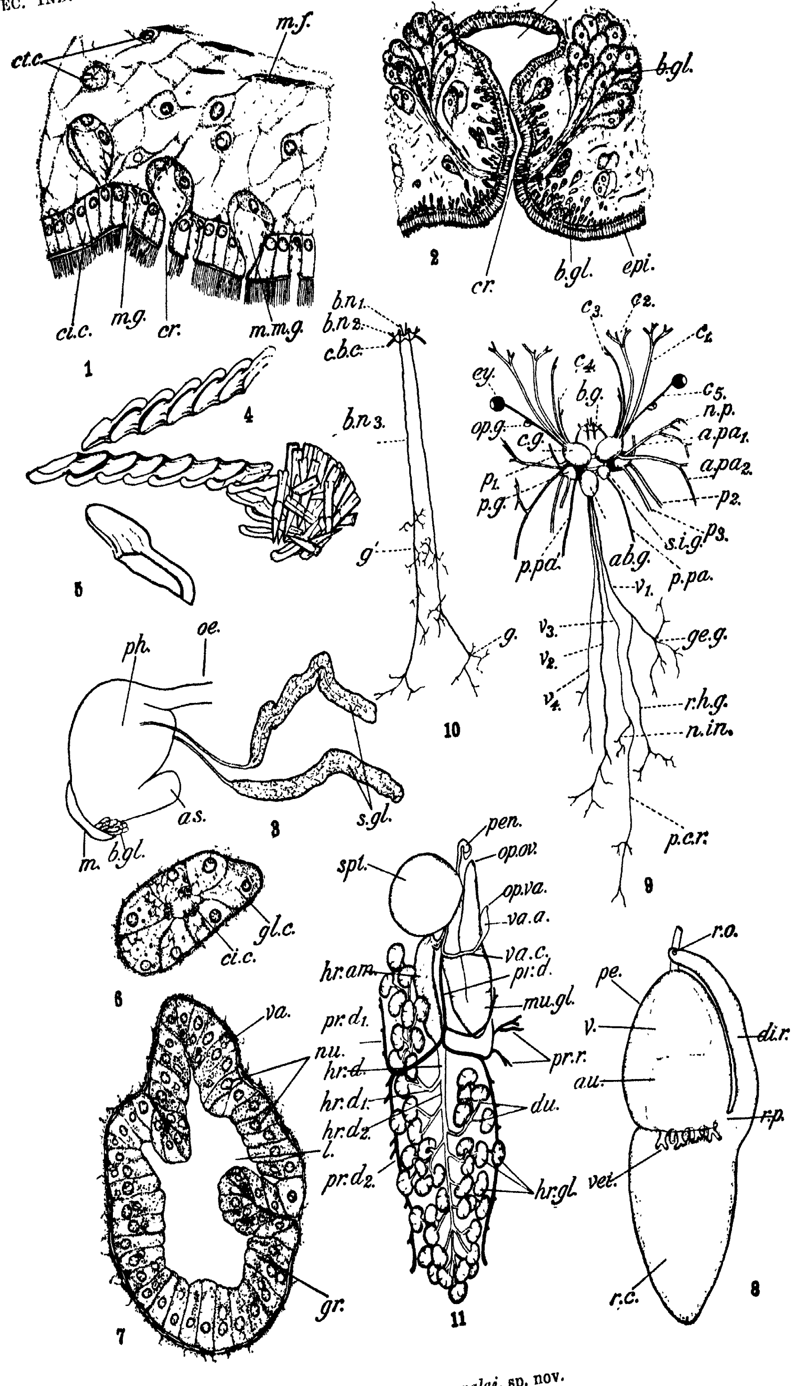
FIG. 7.—Transverse section of the digestive gland in the cerata. $\times 300$.

FIG. 8.—Diagramatic representation of the pericardium containing the heart and its relation to the renal system, reconstructed from serial sections.

FIG. 9.—General view of the nervous system. Highly magnified.

FIG. 10.—The buccal ganglia and their nerves. Highly magnified.

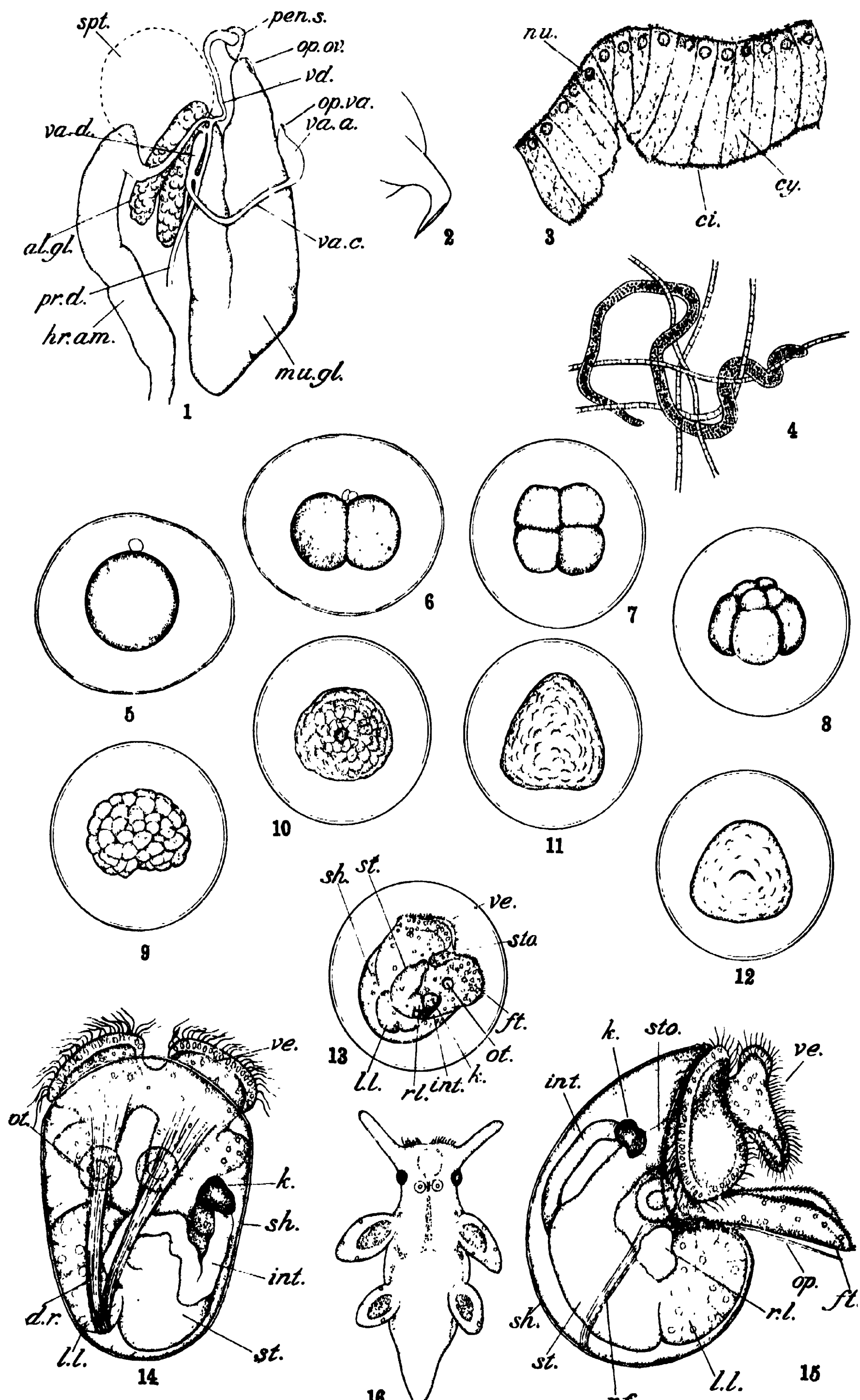
FIG. 11.—General view of the reproductive system as revealed in dissection under the binocular microscope.



Stiliger gopalai, sp. nov.

EXPLANATION OF PLATE IX.

FIG. 1.—Dissection of the anterior genitalia. Highly magnified.
FIG. 2.—Penial stylet. ×300.
FIG. 3.—Section of the mucous gland of the anterior genitalia. ×300.
FIG. 4.—Spawn twisted round the algal threads of *Chatetomorpha*.
FIG. 5.—Egg enclosed in a capsule. ×200.
FIG. 6. Two cell stage. ×200.
FIG. 7.—Four cell stage. ×200.
FIG. 8.—Eight cell stage. ×200.
FIG. 9.—Gastrula at the commencement of the formation of blastopore. ×200.
FIG. 10.—View of the vegetative pole of the gastrula showing the blastopore. ×200.
FIG. 11.—Gastrula at a later stage with a prominent pointed apical end. ×200.
FIG. 12.—The blastopore is seen reduced to a crescentic slit in the gastrula. ×200.
FIG. 13.—Early veliger. ×200.
FIG. 14.—Dorsal view of veliger larva. ×400.
FIG. 15.—Side view of veliger larva. ×400.
FIG. 16.—Metamorphosed young one.



Stiliger gopalai, sp. nov.

INDEX.

[*N.B.*—An asterisk (*) preceding a name denotes a new variety or sub-species; a dagger (†) indicates a new species; a double dagger (‡) a new genus or sub-genus; a double asterisk (**) a new family or sub-family; synonyms are printed in italics.]

Page.

A

Ablepharus . . . 215, **231**, 232
boutoni 232
burnetti 232
cabindae 229, 232
egeriae 232
lineo-ocellatus 232
pannonicus 232
spenceri 231, 232
tenuis 232
Abramis brama 316
Acanthocephala 303
Acanthochitona penetrans . . 70
Acanthodrilidae 306
Acanthonotus 311
Acanthophthalmus 252
Acanthopsis 252
Acentrogobius neilli 68
Acmaea saccharina stellario . . 50
Actaea 400
areolata . . . 378, **399**, 400
calculosa . . . 378, **400**, 401
granulata 401
savignyi 401
semoni 400
Actaeinae 378, 399
Acteonia 440
Actiniidae 371
Actumnus elegans . 379, **408**, 409, 410
setifer 409
Ailia coila 44
Alderia 457
modesta 437
Allolobophora acystis 108
agatschiensis 108
caliginosa trapezoides . 106, **108**
typica 106
dubisa 108
jassyensis . 105, 106, 107, **109**
prashadi . . . 105, 106, 108
ribaucourti 108
Alocinma 277
Ambassidae 18, 20
Ambassis ranga 7, 17, 20
Amblycepidae 339
Amblyceps . . . 252, 253, 254
mangois 339
Amblypharyngodon 321
microlepis 19
Amnicola 277
Amnicola (Alocinma) stenothyroides 277
Amnicolidae . . . 261, **263**, 277
Amphipsyche 113, 116
indica . . . 113, 115, 116
Amyntas 187
aeruginosus 187
alexandri 192

Page.

Amyntas hawayanus 205
heterochaetus 198
posthumus 207
Anagenesia 351, 353
birmanica 370
lata 353
†lontona **352**
minor **353**
picta 353
robusta 353
Anaspis cabindae 227
Andamia heteroptera 68
Andrusovia 261
Anomalopus 219
verreauxi 219
Anotis 223
marei 223
Anthidium 291
Aporrhais pes-pelicanis 55
Apterygodon 226
vittata 226
Ascoglossa 442, 448
Asphondylia 283
†menasché **283**
pongamiae 283
Aspidoparia 321
jaya 44
morar 19, 44
sardina 321
Atergatis dilatatus 397
integerrimus . . . 378, **397**
Ateuchosaurus **231**
chinensis 231
pellopleurus 231

B

Balanus 88
Balitora . . 11, 245, 246, 252, 254
Bagarius . . . 248, 252, 253, 254
Bagridae 18, 19
Barbus 14, 18, 21, 22, 244, 252, 254, 317, 318, 319, 321, 323
ambassis 321
binduchitra 336
caudimarginatus 336
†cauveriensis . . . 19, **20**, 21
chagunio 23
chilinoides 339
chrysopoma 19, 336
clavatus . . . 331, **334**, 335
burtoni . . . 332, **335**, 336
conchonius 339
cosuatus 16, 17, 18
curmuca 14, 20
daniconius 18
dobsoni 14

Page.

Barbus dorsalis . . 7, 16, 17, 19
dubius 19, 20
filamentosus . 15, 18, 19, **22**, 23, 24
juganio 321
hexagonolepis 331, **334**
kolus . 7, 8, 14, 19, 20, 317, 318
lithopidos 19
mahecola . . 18, 22, 23, 24
Mahicola 22
M'clellandi 330
melanampyx 8, 19
micropogon 19
myitkyinae . 331, 332, **334**, 336
†narayani . . . 19, **24**, 25
normani 244
oatesii 336
pinnauratus 7, 8, **9**, 17, 19, 329, 332, **336**
pulchellus 17
putitora 44, 339
regani 244
sarana 336
sewelli 329, 336
sophore 7, 8, 17, 19
sp. 7, 15, 44
spilopholus 23
thomassi 20
ticto . . 7, 8, 16, 17, 19, 330
tor 6, 246
vittatus 16
Barbus cosuatis 321, 322
Barbus (Puntius) †binduchitra 324, **327**, 328, 329
stoliczkanus 324, **330**
Barilius 313
bandelisis . . 7, 8, 44, 339
barila 7, 331, **332**
barna 7
gatensis 19
modestus 44
shacra 44
tileo 44
vagra 43, **44**, 339
Barilius (Opsarius) bola 44
Beaufortia 8, 12
Berosus 40
aeneiceps 40
immaculicollis 40
†insolitus . . 33, 34, 35, **40**
nigriceps . . 33, 34, 35, **40**
puntulatus 34
sp. 35
Berosus (Enoplurus) fairmairei . 30, 31
†fallax **30**
Bhavania . . . 8, 11, 12, 256
annandalei . . 7, 8, **11**, 12, 13
Bhawania 11
Bimastus eiseni 107
indicus . . . 105, 106, 107
norvegicus 110
parvus 107, **111**
tenuis 107, **110**
Bithynia 263
stenothyroides 277
tentaculata 264
kashmirensis 263
Boloceractis 375
Boloceroidaria . . . 371, 375
Boloceroides 371
Boloceroididae 375
Brachydanio 327
choprai **324**, 325
rerio . . . 8, 15, 16, 339
Brachygnatha 378, 388
Brachyrhyncha 378, 391
Brachystopus 230
lineopunctulatus 230
Buccinum lagotis 267
truncatulum 271
Buliminae 263, 277
Bulimus **263**, 277
tentaculatus kashmirensis **263**, 264
Bulimus (Alocinma) 263
stenothyroides **277**
Bulimus (Bulimus) 263
Bulinus 263
Bunodeopsis 371
Bythinia stenothyroides . . . 277

C

Cabdio 321
Calappa hepatica 378, **382**
Calappidae 378, 380, 382
Calappinae 378, 382
Calliopaea 437
bellula 437
dendritica 437
felina 437
souleyeti 437, 444
Calotes 134
Campsodactylus 227
lamarrei 227
vosmaeri 227
Cancer fasciatus 394
Carcininae 378, 391
Carcinus maenus . . 378, 381, **391**
Carpilodes dioderus 396
lippus 396
margaritatus . 378, 381, **395**, 396
Carpiocatla 254
Carassius vulgaris 19
Catla 254
catla 45, 255
Catolaccus 125
tylodermae 125
Cecidomyia 285
†dattai **285**
Cecidomyidae 281
Cerithidae 64
Chaca 252, 253, 256
Chalicodoma 291
Chalidis 440
Chanodichthys 314
Charybdis 393
Charybdis (Goniosoma) annulata 378, **393**
? callianassa 378, **395**
cruciata 378, **392**
lucifera 378, **392**, 393
merguiensis . . . 378, 393, **394**
quadrimaculata 392
Chela 313
argentea 7
baicala **44**
clupeoides 8

Page.
Chelomelis 223
quadrilineatus 223
Chiamela 227
lineatus 227
Chironomidae 53
Chlorodiella niger 378, **402**
Chlorodinae 378, 402
Chlorodius niger 402
Cirrhina 254
fulungee 7, 17, 19
mrigala 255
reba 19
Clariidae 18, 20
Clarius batrachus 20
Clibanarius olivaceus 68, 455
Cliona sp. 70
Clistocoeloma 433
balansae 414, 432, 433
merguiense 379, **431**, 432, 433
tectum 432, 433
Clupisoma garua 44
Cnemaspis littoralis 216
Cobitidae 242, 331, 337, 339
Coelostoma horni 34, 35, **37**
Coleoptera 33
Coloscinus 219
truncatus 219
Cophoscincopus **231**
Cophoscincus 223, 231
quadrivittata 223
simulans 231
Corbicula **274**
cashmiriensis **274**
fluminalis 274
fluminalis oxiana 274, 275
Corbiculidae 261, 274
Corvospongilla lapidosa 115
Crocodilia 160, 167
Crossochilus 246, 252
latius 44, 339
Crustacea 53
Custiphorus vesiculosus 458
Cyclocheilichthys 18, 21, 322, 323
Cyclodina 223
aenea 223
Cyclodomorphus 232
Cyclodus 232
casuarinae 232, 233
flavigularis 232
gigas 232
Cyclopides 99
Cyclops 100
Cyclops (Microcyclops) attenuatus 100
bicolor 99, 100
†diminutus **99**, 103
linjanticus 102
†tricolor **101**, 102
varicans 99, 103
*pachyspina **102**
Cymo melanodactylus 378, **403**, 404
Cyprinidae 18, 19, 241, 331, 332, 339
Cyprinion 45
Cyprinodontidae 18, 20
Cyprinus 45
borelio 321
dancena 321
hoalius 321
jaya 321
Cyprinus solio 321
Cyprinus devario 321
cosuatis 321, 323
cotio 321
gaganio 321
lamta 344
mola 321
Cyprinus (*Garra*) lamta 344, 345
Cyrena 274
Cyrenidae 274

D

Danio 321, 327
†feegradei 324, **325**, 326, 327
malabaricus 7, 19
strigillifer 7, 8, **10**, 11, 16, 17, 18, 336
Danio (*Brachydanio*) *choprae* 324
Dardanus megistos 69
Dasia 213, 217, **226**
dahlii 226
grisea 226
haliana 226
nieuwenhuisi 226
olivacea 226
smaragdina 226
subcoerulea 226
vittata 216, 226
vyneri 226
Dendrobaena kempi 105, 106
rubida 106
subrubicunda 106, **107**
Desmogaster 105
Dicellura 1
Dichogaster 105
Diglochis 126
Diplocardiidae 105
Diptera 281
Diptychus 43
annandalei 43
maculatus 241
Dotilla clepsydrodactylus 423
intermedia 379, **422**, 423

E

Eagle marmelos 281, 286
Earthworms 105
Echinus esculentus 68
Eisenia foetida 106, **107**
rosea 106, **107**
Eiseniella tetraedra typica 105, 106, **107**
Elania 222
Elysia viridis 441, 445
Embletonia 437
mariae 437
Emoia 213, 217, 223, **226**, 232
acrocarinata 227
adspersa 226
atrocostata 216, 227
ahli 227
battersbyi 227
baudinii 227
buergersi 227

Page.
Emoia callisticta 227
cunieceps 227
cyanogaster 227
cyanura 227
flavigularis 227
iridescens 227
jakati 227
klossi 227
kukenthali 227
mehelyi 227
mivarti 227
murphyi 227
nigra 226
pallidiceps 227
parietale 226
ruficauda 227
samoensis 227
sanfordi 215, 216, 227
similis 227
sorex 227
speiseri 226
spenceri 232
tetrataenia 227
tropidolepis 227
werneri 227
whiteneyi 227
Enochrus 38
Enochrus (Lumetus) bicolor . . 38
fragilis 39
fretus 39
†sinuatus . . . 33, 34, 35, **38**
Enochrus (Methydrus) tetraspilus 34, 35, **39**
Eosentis 303
devdevi 303, 304
rigidus **303**
yalei 303
Eolidina paradoxum 440
Eophila 110
cryptocystis 108
†himalayana . . . 105, 106, 107, **109**
mariensis . . . 105, 106, 107
tyrtea 110
Ephemera 351, 355
annandalei . 351, **360**, 363, 368
consors **368**
diffusa . . 351, **355**, 356, 357, 359, 364, 365
expectans . 359, 360, 362, **366**
fasciata 366
fulvata 355, 370
immaculata . . 359, **363**, 364, 365
pulcherrima **368**
remensa **368**
supposita . . . 356, **366**, 367
vedana 366
Ephemeridae 355, 370
Ephemeroidea 351, 352
Ephemeroptera 351
Epexochlaenoides . . . 287, 289, **300**
bicinctus 300
pyriformis **300**
Epixanthus frontalis . . . 379, **405**
Ercolania . 437, 438, 442, 447, 457, 458
panceri 458
siottii **441**, 458
uzilli 458
Page.
Erethristes . . 246, 252, 253, 256
Eriphinae 379, 410
Esomus barbatus . . 7, 8, 16, 17, 19
Euchiloglanis 243, 252
blythii 43
Euderus gossypii . . . 125, **127**
†pempheriphila **127**
Eugongylus 227
Eulamellibranchiata 274
Eulamprus 219
lquoyi 219
Eulepis 223
Eulophidae 127
Eumeces microlepis 227
oppelii-rufescens 227
punctatus 227
Eumecia 227
anchietae 227
Euprepes ernesti 226
Eusoma 226
cyanura 226
lessoni 226
Eutyphoeus . 187, 305, 306, 307, 308, 309, 310
Exochlaenus 290, 291
Exostoma 243, 252

F

Fiona marina 452, 453
Foraminifera 53

G

Gagata 252, 253
Galvina 439
picta 456
Garra . 6, 245, 246, 252, 253, 254, 339, 344, 348
bicornuta 7
ceylonensis ceylonensis . . 348
gotyla . . 331, **333**, 334, 339, 347, 348
gravelyi 340
jerdoni . . . 7, 16, 17, 19
lamta . 340, 344, **345**, 346, 347, 348
mullya 19
prashadi . . . **339**, 340, 341
stenorhynchus 19
Gastromyzon 8, 12
Gastromyzoninae 8, 12
Gastropoda 261, 277
Gecarcinucinae 379, 418
Geckonidae 216
Gelasimus *acutus* 422
manii 379, 380, **422**
marionis 379, **422**
excisa 422
nitidus 422
nitidus 422
triangularis 379, **421**
Glaridoglanis 243
Glabropilumnus 407
Globopilumnus 408
Globopilumnus globosus . . . 408

	Page.
Glossogobius giuris	7, 20
Glyptosternum	242, 243, 245, 247, 248, 257, 350
hodgarti	43
maculatum	243, 350
reticulatum	243
Glyptothorax	245, 246, 252, 253, 350
dekkanensis	7, 8, **14**
madraspatanus	19
pectinopterus	339, 350
trilineatus	331, 332, **338**
Gobiidae	18, 20
Gonoplacidae	379, 380, 381, 411
Gonorhynchus lamta	345
Gordiodrilus	105
Grapsidae	379, 380, 381, 425
Grapsinae	379, 425
Grapsus grapsus	425
strigosus	379, 380, **425**
Gymnodactylus frenatus	216
Gyraulus	**272**, 273, 279
convexiusculus	**279**
ladacensis	272, **273**
pankongensis	**272**
sp.	279
Gyrostoma	371
glaucum	371, 376

H

Hagria	227
Halimus	389
Haliotis tuberculata	51
Haliotis (Sulculus) gigantea	71
Haplochilus panchax	331
Helicophagus	**235**, 236, 239
typus	236, 237
waandersi	235, 236, 237, 238, 239, 240
Helix auricularia	266
stagnalis	265
tentaculata	263
Helochares (Agraphydrus)	29, 34, 37
coomani	37, 38
†exedis	**29**
kempi	37, 38
orientalis	38
pauculus	38
puntatellus	38
pygmaeus	38
†stagnalis	33, 35, **37**
Hemiergis	213, 223
Hermaea	438, 442, 457
dendritica	437
Hermaeidae	437, 457
Heteronucia	388
mesanensis	378, 381, **385**, 386, 387, 388
venusta	388
vesiculosa	388
Heteropilumnus	417
Heteropilumnus angustifrons	411
Heteropneustes fossilis	19
Heteropneustidae	18, 19
Heteropus	223
Hexagenia	355, 369
indica	355, **369**
Hinulia	219
Homaloptera	11, 12
Homalopterinae	8, 12
Hombronia	223
fasciolaris	223
Homolepida	213
casuarinae	213
Hormomyia	284
†calcuttaensis	**284**
ischaemi	284
subaptera	284
Howascolex	105
Hyastenus	389
hilgendorfi	378, **388**
sp.	378, **389**
Hydraenidae	35
Hydrophilidae	29, 35
Hydropsyche	116
Hydropsychidae	113
Hymenoptera	287

I

Ictiscincus	222
Indoplanorbis	**279**
exustus	**279**
Isopachys	230
gyldenstolpei	230
Itonida	285
Itonididae	281

J

Janellidae	273, 274

K

Kalinga ornata	442
Keneuxia	226
smargdinus	226

L

Labeo	252, 254
bogut	19
dero	9, 24, 44, 45, 333, 339
devdevi	231, **333**
dussumieri	19
dyocheilus	43, 44, **45**, 333
porcellus	7, 8, **9**
rohita	255
Labeo (Labeo) *dyocheilus*	333
Labauca atpar	7, 16, 17
laubuca	44
Laccobius gracilis	33, 35, **37**
simulans	35, **37**
Lacerta	134, 135, 143, 144, 148, 150, 151, 156, 161, 173
Lacertidae	215
Lacertilia	133, 134, 156
Laguvia	246
Lampito	187
Lamprolepis	226

	Page.
Lampropholis	223
Leiocassis	252
Leiolopisma	213, 219, 223, 234
Lepidocephalichthys	252, 253, 254
berdmorei	332, **337**
guntea	339
thermalis	7, 8, 16, 17
Leptodius cavipes	378, **398**
exaratus	378, 380, **398**
Leptosoma	230
bougainvillii	230
Lestremia †calcuttaensis	**281**
ceylonensis	281
indica	281
Leuciscus	26
caverii	26
flavus	26
mahecola	22, 24
malabaricus	26
Leucosiidae	378, 380, 381, 385
Leucosiinae	378, 385
Leucospidinae	287, 288
Leucospis	287, 288, 289, **290**, 291, 300
anthioides	291
assamensis	292, 294, **296**
atra	298
bengalensis	287, 291, 293, **297**, 298, 299
mackenziei	292, 293, **298**
bombayensis	291, 293, **298**
†darjilingensis	292, **294**, 295
guzeratensis	288, 291, 293, **298**, 299
indiensis	291, 292, **293**
malabarensis	291, 292, **295**, 297
meenakshiae	291, 292, 294, **296**, 299
nursei	291, 292, 293, 295, **297**
ornatifrons	292, 293, 294, **295**, **296**, 299
petiolata	298
quettaensis	291, 292, 293, 295, **297**
ramkrishnai	292, 293, **299**
viridissima	291, 292, **295**
Limapontia	446, 458, 459
capitata	451
nigra	447
Limnaea auricularia var. *ventricosa*	266
brevicauda	270
defilippi	269
lagotis	267
costulata	268
defilippii	269
solidissima	268
striata	267
lagotis	268
plicatula fasciolata	267
stagnalis	265
kashmiriensis	265
minor	265
Limnaea (*Gulnaria*) *auricularia ventricosa*	266
brevicauda	270
lagotis	267
striata	267
Limnaea (Radix) lagotis	267
Limnaeus truncatulus	271
Lioscincus	223
steindachneri	223
tricolor	223
Liosoma	227
Liotropis	226
olivacea	226
Lipinia	223
pulchella	223
Lissonota	219
maculata	219
Lithophaga	70
Lithophaga (Lithophaga) laevigata	70
nasuta	70
Litocheira	416, 417
amoyensis	416
angustifrons	379, 381, **411**, 413, 414, 415, 416, 417
beaumontii	417
bispinosa	416, 417
ciliata	415
cristata	414, 415
integra	416
quadrispinosa	416
setosa	416, 417
subintegra	414, 416
hirsutior	416
Littorina scabra	50
Lumbricidae	105
Lumbricus rubellus	107
Lupinae	378, 391
Lygisaurus	223
foliorum	223
mundus	223
Lygosaurus	231
pellopleurus	231
Lygosoma	213, 214, 215, 217, 218, **219**, 222, 223, 231, 232, 233
acutum	219
aeneum	223
aequale	221
aignanum	219
albertisii	214, 232
alfredi	221
aloysi-sabaudae	221
anolis	215, 216, 224
antoniorum	221
atrigularis	221
australe	221
austro-caledonicum	225
becarrii	225
bicarinata	225
bilineatum	224
biparietalis	221
blackmanni	225
brevipes	221
cameronicus	220
challengeri	224
clathrotis	221
cophias	221
courcyanum	221
curtum	225
decipiens	220
decresiense	224
delicatum	214, 225
dendyi	223
deplanchi	220

Page.

Lygosoma devisii 225
doriae 224
dorsale 220
duperreyi 223
dussumieri 219
elegans 224, 234
emigrans 220
entrecasteauxi . . . 224, 232
euryotis 225
fallax 220
fasciolatum 219, 220
fischeri 220
flavipes 224, 234
florense 219
forbesi 221
fuscum 223, 225
gracile 224
grande 223
graueri 221
guichenoti 223, 225
helenae 221
himalayana 224
himalayanum 232
homalonotum 223
indicum . . 215, 216, 220, 222
initiale 225
infralineolatum 225
infrapunctatum 224
isolepis 220
jugori 220
labillardiri 220
ladacense 224
larutense 221
laterimaculatum 224
leae 220
lesueri . . . 214, 219, 220
lichenigerum 224
lineo-ocellatum 223
longiceps 224
lousiadense 219
luzonense 221
maccooeyi 225
maccoyi 224
maculatum . . 215, 218, 219
maindroni 219
malayanum 220
mariae 224
melanopogon . . 215, 218, 219
meleagris 221
metallicum 225
minutum 220
miodactylum 221
miotis 225
mjobergi 221
moco 223
modigliani 220
monotropis . . 214, 219, 220
morokanum 225
mundivense 225
mundum 225
mustelinum 224
nigrigulare 225
nigrofasciolatum 224
nigrolineatum 220
noctua 224
nototaenia 224
novae-caledoniae 225
novae-guinae . . . 223, 225

Page.

Lygosoma ocellata 225
ocelliferum 220
ornatum 220, 223
pallidum 220
palnicum 225
pardalis 220
†parkeri 224, 234
pectorale 225
peroni 224
presigne 220
pretiosum 225
pulchellum 224
pulchrum 225
pumilum 221
punctulatum 221
quadrilineatum 224
quadrivittatum 225
quadrupes . . 214, 219, 221
quoyi 219, 220
reevesi 223, 224
relictum 225
reticulatum 221
rhomboidale 225
richardsoni 220
rufum 220, 222
rupicola 224
sanctum 215, 219
scharffi 224
scotophilum 215, 219
semoni 224
serpens 219
scutirostrum 221
shelfordi 220
sikkimense 224
smithi 223
spinauris 225
stanleyanum 225
steeri 221
steindachneri 225
stellatum 219, 220
strauchi 219, 220
striatopunctatum 220
striolatum 219
sumatrense 221
surdum 229
suteri 223
taeniolatum 220
taprobanense 220
telfairi 224
temmincki 221
tenue 220
tersum 220
tetradactylum 225
textum 221
travancoricum 225
tricolor 225
trilineatum . . 223, 225, 232
truncatum 221
undulatum . . 219, 220, 222
unicolor 224
variable 225
verreauxi 213, 221
vigintiserium 221
vittigerum 224
woodwardi 224
Lygosoma (Emoia) muelleri . 214, 215
pratti 215
Lygosoma (Hinulia) compressicauda 214

Page.
Lygosoma (Ictiscincus) 222
crassicauda 222
loriae 222
muelleri 222
oligolepis 222
pratti 222
solomonis 222
woodfordi 222
woolastoni 222
Lygosoma (Siaphos) compressicauda 214
Lygosoma punctata 227
Lygosomella 223
aestuosa 223
Lymnaea . . . 261, **264**, 269, **278**
acuminata **278**
hians **278**
typica **278**
auriclaria . 264, **266**, 267, **269**
brevicaudata . . . 266, **270**
lagotis . . 266, **267**, 268, 269
costulata . . 267, **268**, 269
defilippii . . . 267, **269**
solidissima . 267, **268**, 269
striata . . . **267**, 268
subdisjuncta . . 268, 269
luteola **278**
ovalis 278
obliqua 268
persica 266
sp. 262
stagnalis . . 264, **265**, 269
kashmiriensis **265**
minor **265**
sirikulensis 269
truncatula . . 264, 270, **271**
Lymnaea (Galba) . . . 264, **270**
truncatula 271
Lymnaea (*Gulnaria*) 266
Lymnaea (Limnaea) . . 264, 265
Lymnaea (Pseudosuccinea) . . 278
Lymnaea (Radix) . . . 264, **266**
auricularia 266
Lymnaeidae . . . 261, **264**, 278

M

Mabuia 134
Mabuya 223
Macrodactyla 371
Macronema 113, 116
Macrophthalminae 379, 423
Macrophthalmus convexus 379, **423**, 424
erato 379, **424**, 425
eratus 424
telescopicus 379, **423**
verrauxi 423
Macropodus cupanus . . 16, 17, 20
Maiidae 378, 380, 388
Maiinae 378, 390
Marphysa 68
Marres . . . 287, 288, 289, 290
Mastacembelidae . . . 18, 19, 339
Mastacembelus armatus . 7, 16, 19, 339
Matsya . . . 311, 312, 313, 314, 315, 318, 319
argentea 311, 314, 315
caldwelli 314

Page.
Matsya denticulatus 314
elongatus 314
hollandi 314
nigrodorsalis 314
pingi 314, 318
Matuta 383
flagra 384
lunaris . . 378, 380, **383**, 384, 385
lunaris 384
planipes . . 378, 383, **384**, 385
victor 383, 385
Matutinae 378, 383
Medusidae 440
Megachile 291
Megalobrama 314
Megascolecidae 105, 306
Megascolecinae 306, 307
Megascolex 187, 211
affinis 207
diffringens 198
houlleti 203
iris 187
margaritaceus 187
mekongianus 187
pictus 187
posthuma 207
Megascolides 305
Megascolides bergtheilo . . 305, 307
Menippe rumphii . . . 378, **404**
Menippe (Myomenippe) *granulosa* . 404
Menippinae 378, 404
Metapachia 125
Metaplax dentipes . 379, 380, **433**, 434
Microcyclops 99, 100
leuckarti 102
rylovi vermifer 102
Micromyia †indica **281**
Mochlus 227
punctulata 227
Mocoa 223
guichenoti 223
zeylandica 223
Mollusca 53
Mugil cephalus 129, 131
Mya arenaria 63
Myomenippe *granulosa* 404
hardwickii . . 378, **404**, 405
Myonanthus 371
Myophila 223
? blackmanni 223
vivax 223
Mystacoleucus . 311, 312, 313, 314, 315, 317, 318
atridorsalis 312
chilopterus . . . 311, 312, 314
marginatus . 311, 312, 313, 314, 316, 317, 318
ogilbii . . . 312, 313, 314, 316, 317, 318
padangensis 312, 314
Mystus aor 19
cavasius 17, 19
malabaricus 19
montanus 19
punctatus 19
vittatus 19
Mytilus californianus 66, 68
edulis 66

Page.

N

Nangra 252, 253
    viridescens 19
Nannoscincus 223
    fuscus 223
    marei 223
Nemachilichthys 6, 14
    shimogensis 7, 17
Nemachilus . 6, 14, 242, 243, 248, 252, 253, 254, 257, 340
    anguilla 7, 8, **13**
    bevani 339, **341**
    †bhimachari 7, **13**, 14
    botia 339
    dayi 8, 19
    denisonii 7, 8, 16, 19
    rupicola inglisi 44
    scaturigina 44
    sinuatus 16
    sp. 341
    striatus 7, 8, 12, 13
    vinciguerrai 331, **337**
Neocatolaccus **125**, 126
    australensis 125
    †indicus **126**
    livii 125
    sphenopterae 125, 126
    subviridis 125
    syrphidis 125
    tylodermae 125
Neoechinorhynchus. . 129, 130, 131, 303
    †chilkaensis **129**, 130
Neogastromyzon **8, 12**
Neolasioptera cephalandrae . . . 283
    crataevae 283
    †variipalpis **282**
Neptunus (Neptunus) sanguinolentus 378, **391**, 392
Nerita albicella 50
    chameleo. 50
    polita 50
Neritidae 64
Nevadne 371, 375, 376
    glauca 371,373, 376
Nitocris 187
    gracilis 187

O

Obelia geniculata 456
Ochthebius andraei 36
    †explanatus 33, 34
    †flumineus 33, 34
    reflexus 36
    sp. 35
Ochthebius (Doryochthebius) . . . 36
Ochthebius (Hymenodes) aeneo-cupreus 34
    difficilis 34
    †explanatus 35, **36**
    †flumineus . **34**, 35, 36, 37
    schneideri 34
Octochaetinae 307
Octolasium cyaneum . 105, 107, **111**
    lacteum 107, **111**
Ocypoda ceratophthalma 379, **418**, 419, 420
    cordimana 379, **420**
    macrocera . 379, 418, **419**, 420, 422
Ocypodidae 379, 380, 418
Ocypodinae 379, 418
Octhra scruposa 378, **390**
Oligosoma 223
    moco 223
Olyra 252, 254
Omolepida 232, 233
Ophicephalidae . . 8, 18, 20, 331, 338, 339
Ophicephalus 8, 15
    gachua . . 7, 9, 15, 16, 18, 20, 331. **338**, 339
    morulius 20
    punctatus . 7, 15, 17, 20, 43, 44
    spp. 15
Ophioscincus 230
    australis 230
Opsariichthys. 313
Oreichthys 322, 323
    cosuatis 322, 323
    parvus 323
Oreinus . 242, 244, 252, 257, 258
    molesworthi 331, **332**
    richardsoni 43, 44
    sp. 44
Oreoglanis 243
Orseoliella apludae 285
    †bengalensis **285**
Osmia 291
Osphronemidae 18, 20
Osteobrama 314
Osteochilus 10
    malabaricus 10
Otosaurus 213, 217, **218**
    amblyplacodes 218
    annectens 218
    anomalopus . . . 215, 216, 218
    celebense. 218
    concinnatum 217, 218
    cumingi 218
    curtirostris 218
    granulatum 215, 218
    jobiense 218
    kinabaluense 218
    llanosi 218
    mimicanum . . . 215, 216, 218
    murudensis 218
    nigrilabre 218
    sarasinorum 215, 218
    simum 218
    tropidonotus 218
    variegatum 218
Oxyrhyncha 378, 388
Oxystomata 378, 382
Ozinae 379, 405

P

Palingeniidae . . . 351, 352, 370
Palmipes membranaceus 55
Palpicornia 33, 35
Panaietis camerata 70
    haliotis 71
Panaspis 227, 232
    aeneus 227

Page.
Panchax blochii 20
lineatus . . 8, 15, 16, 17, 20
panchax 324, **331**
Pangasianodon 254
Pangasius . 117, 235, 236, 239, 240
hypophthalmus 236
micronema 239, 240
pangasius . 117, 118, 119, 120, 122, 123, 236, 237, 238, 239, 254, 255
? *Paraberosus melanocephalus* . . 40
nigriceps 40
Parabramis . . 314, 315, 316, 319
cunma 315
Parapholas quadrizonata . . 70
Parapseudecheneis . . . 349, 350
pavaiei 349
Parapsilorhynchus 256
Parapteromalus . . . 125, 126
Parasilurus . . . 252, 254, 343
asotus 343
cinereus 343
cochinchinensis 343
grahami 343
mento 343
Paratelphusa (Phricotelphusa) callianaria 379, **418**
Parosteobrama 314
Parotosaurus 218
annectens 218
Parthenopidae . . . 378, 380, 390
Parthenopinae 378, 390
Pätella vulgata 48, 57
Patella (Patellidea) tara . . . 70
Pelecypoda 274, 280
Pelthydrus 30
†similis **29**
vitalisi 30
Pempheres affinis . . . 125, 127
indica 127
Perichaeta 187, 211
bicincta 195
burliarensis 211
campanulata 197
crescentica 203
cupulifera 205
elongata 201
hawayana 202
houlleti 203, 210
hulikalensis 211
lawsoni 211
mirabilis 198
morrisi 205
posthuma 207
robusta 209
taprobanae 209
travancorensis 203
viridis 187
Peromeles 219, 223
Petrosia 70
Pheretima . 105, 175, 176, 177, 182, 183, 185, 186, **187**, 188, 191, 195, 197, 201, 211
alexandri . 175, 176, **178**, 179, 180, 186, **192**, 195
anomala . . 175, 176, **179**, 180, **182**, **186**, 188, **189**, 191, 192, **193**, **194**, 195
Pheretima austrina **186**
barbadensis 210
barbadensis 205
bicincta . 175, **185**, 186, 188, 191, **195**
birmanica 186
biserialis 201
burliarensis . . 176, 187, 211
californica 187
campanulata . 175, **180**, 181, 186, 191, 192, 195, **197**, 203, 204, 210
penetralis 197
choprai 186
crescentica 203
diffringens . 175, 177, 179, 180, 181, 182, **183**, 184, 186, 187, 189, 192, **198**
doliaria 186
elongata . 175, **185**, 186, 188, 191, 192, **201**
exigua 186
guillelmi 203
hawayana . 175, **184**, 186, 191, **202**, 210
typica 202
hawayana 205, 206
barbadensis 205
typica 205
heterochaeta . . . 177, 198
himalayana 185, 209
houlleti . 175, 176, 180, **181**, 186, 191, 192, **203**, 204, 205
houlleti 197
hulikalensis 211
immerita 181, 182
lawsoni 187, 211
lingicola 176, 192
meridiana . 180, 181, 203, 204
mirabilis 198
montana 187
morrisi . 175, **184**, 186, 191, **205**, 210
peguana 176, 186
planata . 175, **181**, 182, 186, 191, **207**
posthuma . 175, 177, **182**, 186, 187, 191, 192, **207**
robusta . . 175, **185**, 186, 191, **209**
stelleri 185, 201
stuarti 211
suctoria 192
mullani 193
taprobanae . 175, **185**, 186, 188, 191, **209**
travancorensis . . 176, 203, 204
trivandrana 176, 203
udekemi 203
violacea 195
waltoni 187
Pheretima (Polypheretima) . 185, 201
Philyra scabriuscula . . 378, **388**
Pholeophilus 230
capensis 230
lineata 230
Physignathus 230
Phytocoeteopsis . . . 375, 376
ramunnii 371, 376
Pilumninae 379, 406
Pilumnoplax ciliata 412

Page.

Pilumnus 409
andersoni 406
globosus 408
hirsutus 379, **407**
longicornis 379, **406**
seminudus 407
Pisidium 275, **280**
clarkeanum **280**
hydaspicola **275**
stoliczkanum **275**
zugmayeri **275**
Pisidium (Eupisidium) 275
Pisidium (*Fossarina*) zugmayeri . 275
Pisinae 378, 388
Planorbidae . . . 261, **271**, 279
Planorbis **271**, 279
corneus 271
planorbis. 271
tangitarensis 272
Planorbis (*Anisus*) *subangulatus* var. 272
Planorbis albus 272
andecolus 272
choanomphalus 272
convexiusculus. 279
exustus 279
glaber 272
Nevilli 273
Planorbis (*Gyraulus*) *albus* . . 272
albus var. 272
convexiusculus. 279
ladacensis 273
Planorbis (*Gyraulus*) *laevis ladacensis* 273
Nevilli 273
pankongensis 272
saigonensis 279
Planorbis (*Planorbis*) exustus . . 279
Planorbis (*Tropidiscus*) planorbis
tangitarensis 272
subangulatus var. 272
Polistomorpha . 287, **288**, 289, 290
bulbiventris 289
fasciata 289, 290
indica 289, **290**
nigrimaculata 289
nitidiventris 289
paivai 289, **290**
sphegoides 289
surinamensis 289, 290
Polymitarcidae . . 351, 354, 370
Polymitarcys birmanus 370
indicus **354**
Pontoscolex corethrurus 182
Portunidae . . 378, 380, 381, 391
Potamanthidae 351, 369
Potamanthodes 369, 370
formosus **369**
Potamanthus 369
subcostalis 369
Potamanthus expectans 366
fasciatus 366
formosus 369
Potamon sp. 379, 418
Potamon (Acanthotelphusa) dayanum
379, **417**
Potamonidae 379, 380, 417
Potamoninae 379, 417
Praepeditus 230
Projapygidae 1

Page.

Promegascolex 187
mekongianus 187
‡Propseudecheneis . . **348**, 349, 350
†tchangi **348**, 349
Prosobranchia 261
Pseudecheneis . 243, 245, 252, 254,
348, 349, 350
sulcatus 348, 349
Pseudeutropius taakree . . . 18, 20
Pseudocatolaccus 125, 126
Pseudogastromyzon 8, 12
Pseudorhombilinae . . . 379, 411
Psilorhynchus . . . 246, 252, 254
Pteromalidae 125
Pterochilus viridis 437, 458
Pulmonata 264
Puntius 18
Puntius filamentosus 22
Puntius (*Capoeta*) *lepidus* . . . 24

R

Radiolaria 53
Rasbora 26
caverii 18, 19, **26**, 27
daniconius . 7, 8, 16, 17, 19, 26,
324
rasbora 26
Reptilia 213
Rhodona 214, 217, **230**
anguinoides . . . 214, 230, 231
australe 231
bipes 231
bougainvillii 230
fragile 230
frosti 230
gerrardi 230
lineata 231
lineopunctulata 230, 231
macropisthopus 230
microtis 230
miopus 231
nichollsi 230
ophioscincus 230
picturata 230
planiventralis 230
pumila 230
punctata 230
punctatovittata 230
roulei 230, 231
terdigitatum 230
walkeri 230
wilkinsi 230
Rhodopis 187
javanica 187
Rhoenanthodes 369
amabilis **369**
Rhoenanthus 369
posticus **369**
Rhoenanthus amabilis 369
Rhynchium nitidulum 300
Riopa . . . 213, 214, 215, 217, 223,
227, 230
africanum 232
modesta 230
vinciguerra 230
Riopa (Emoia) anchietae . . . 214

Page.

Riopa (Eugongylus) **229**
albofasciolata 229
garnieri 229
mentovaria 229
microlepis 229
rufescens 229
sulaense 229
Riopa (Eumecia) **229**
anchietae 230
johnstoni 230
Riopa (Panaspis) **229**
africanum 229
brevipes 229
cabindae 229
kitsoni 229
reichenovei 229
togoense 229
Riopa (Riopa) **228**
albopunctatum 228
anguiana 228
bampfyldei 228
bowringi 228
corpulentum 228
fernandi 228
guentheri 228
guineense 228
herberti 228
isodactyla 228
koratense 228
lineata 228
lineolata 228
mabuiformis 228
mocquardi 228
modestum 228
opisthorhodum 228
producta 228
punctata 228
sundevalli 228
tanae 228
vinciguerra 228
vosmaeri 228
Rissoidae 64
Rocellaria sp. 70
Rohtee . 312, 313, 314, 315, 316, 317, 318, 321
bakeri 312, 315
belangeri . . . 312, 314, 315
cotio 312, 313, 315
cunma 313, 314
duvaucelli . . 17, 312, 316, 317
feae 312
marginatus 317
microlepis 315
neilli 19
ogilbii . . 19, 312, 313, 318
vigorsii 312
Ronia 230
catenulata 230
lineopunctulata 230

S

Saccobranchus fossilis 43
Sagitta . 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 94, 95, 96, 97
bedoti 84, 90, 91
bipunctata **83**, 91
bombayensis 84, 90

Page.

Sagitta enflata 83, 84, 85, 86, 87, 90, 91, 94, 95, 96, 97
ferox 84
gardineri . 84, 85, 86, 87, 89, 90, 91, 94, 95, 96, 97
hexaptera 91
hispida . 83, 84, 85, 86, 87, 91, 94, 95, 96, 97
lyra 91
neglecta . 84, 85, 86, 87, 91, 94, 95, 96, 97
planktonis . 83, 84, 85, 86, 87, 91, 94, 95, 96, 97
polydon 84, 91
pulchera 84, 91
regularis 84, 91
robusta . 84, 85, 86, 87, 91, 94, 95, 96, 97
septata 84, 91
serratodentata . . . 84, 91
subtilis 83, 84
tenuis . 84, 85, 86, 87, 91, 94, 95, 96, 97
tricuspidata 84, 91
Salmacis bicolor . . . 65, 68, 455
Saptadanta nasika 70
Sauroscincus 223
braconnieri 223
Scaphiodon nashii . . . 7, 8, **9**, 10
thomasii 19
Scelotes 223
Schilbeidae 18, 20, 240
Schizocypris 245
Schizophrys asper . . . 378, **390**
Schizopygopsis 242
Schizothorax . 43, 242, 244, 245, 246, 247, 252, 257
esocinus 241
zarudnyi 303, 304
Schizothoracinae . 241, 242, 244, 245, 246, 257, 258
Scincidae 213
Scincus atrocostatus 226
muelleri 222
smaragdinus 226
telfairii 223
vosmaeri 227
‡Scolioscolides **305**, 306
bergtheili **307**
Scopimerinae 379, 422
Scylla serrata . . . 378, 380, **391**
Semiplotus . 43, 45, 46, 252, 253, 256
cirrhosus 46
modestus 45, 46
semiplotus . . . 44, **45**, 46, 254
Sepsina 223
Sesarma 431
bataviana 430
erythrodactyla 430
melissa 430
plicata 429, 430
quadratum 430
Sesarma (Chiromantes) bidens 379, 380, **431**
Sesarma (Parasesarma) 430
obliquiformis 430
†prashadi 379, 381, **426**, 429, 430, 431

Page.

Sesarma (Parasesarma) rutilimana . 431
Sesarma (Sesarma) taeniolata . 379, **428**
Sesarminae 379, 426
Sewellia 8, 12
Siaphos 213
Siaphos 219
aequalis 219
Silonia 254
silondia 255
Siluridae 241
Siluroidea 18
Silurus . . 11, 256, 341, 342, 343
glanis 343
†sinensis . . **342**, 343
wynaadensis . . . 342, 343
wynaadensis . . 341, 342, 343
Sisor 246, 253
Sisoridae . 18, 19, 331, 338, 339, 242
Smiliogaster 314
Somileptes 252
Soridia 230
lineata 230
Spadella 88
cephaloptera 88, 90
Sphaerium 261, **276**
borneense 276
cecilae 276
†kashmirensis . . 261, **276**, 277
montanum . . . 276, 277
sp. 277
Sphenodon . 134, 139, 143, 145, 146, 147, 148, 151, 160, 167, 173
Sphenomorphus . . 213, 214, 219
melanopogon 219
Sphenoptera gossypii . . 125, 127
Sphenosoma 227
Spinibarbichthys . 311, 312, 314, 318
Spinibarbus . . 311, 312, 314, 318
Sponges 53
Sternolophus rufipes . 33, 34, 35, **39**
Stiliger . 435, 436, 437, 438, 440, 441, 442, 444, 447, 450, 457, 458
bellulus . 437, 438, 440, 441, 442, 451, 457, 458, 459
felinus 437, 458
†gopalai . 435, 437, **438**, 440, 442, 445, 447, 451, 452, 453, 455, 456, 457, 458
irregularis 437, 458
mariae 441, 457
modestus 437
ornatus . . . 436, 437, 458
pica 437, 451, 458
souleyeti . 441, 444, 451, 457
tentaculatus . . 437, 442, 458
varians . . . 437, 441, 458
viridis 437
Stiligeridae 437, 457
Succinea **273**, 274
indica **274**
Succineidae 261, **273**
Symphylurinus 1
grassii 4
†indicus **1**, 2
†orientalis **2**, 3
Systomus assimilis 24
filamentosus 24
madraspatensis 24

T

Tergipes 439
edwardsii 455
lacinulatus 455
Tetradactylus 223
decresiensis 223
Tetralia glaberrima . . . 379, **411**
Thalamita prymna 378, **395**
Theconyx 226
halianus 226
Thynnichthys 11, 256
Thysanura 1
Tiliqua 213, **232**, 233
adelaidensis 233
branchiale 233
casuarinae 233
gastrostigma 233
gigas 232, 233
nigrolutea 233
occipitalis 233
scincoides 233
wood-jonesi 233
Tiliqua dura 231
Tincta tincta 316
Tivela stultorum 51
Tonoscolex 307
Trapezia areolata 410
cymodoce 379, **410**
areolata 410
ferruginea 410
areolata 379, **410**
maculata 410
Tridactylus 223
decresiensis 223
Trishormomyia †indica **284**
Trochidae 47, 64
Trochomorphidae 273, 274
Trochus . 47, 48, 49, 52, 55, 57, 65, 69, 71
conuloides 55
lineatus 55
maculatus 47
magus 55
maximus 48
niloticus . 47, 48, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72
obeliscus 47
pyramis 47
Trochus (Gibbula) 55
Tropidophorus 231
Tropidoscincus 223
aubrianus 223
Turbinidae 64
Turbo 69
marmoratus 55
Turbo (Batillus) cornutus . . . 71
Turritella communis 55
Typhloseps 230
roulei 230

U

Uca manii **422**
marionis **422**
Uromastix **134**, **160**

Page.

V

Valvata 261, **262**
piscinalis **262**
ambigua 262
Valvatidae **261**, 262
Varanus . 133, 134, 144, 145, 146, 148, 156, 160, 161, 167, 172, 173
bengalensis 134
griseus 134
monitor . 133, 134, 135, 136, 143, 149
niloticus 133
salvator 133, 134
varius 133, 149
Varuna litterata . . 379, **425**, 426
Varuninae 379, 425
Vermetus (Spiroglyphus) andamanicus 70

Page.

W

Wallago 254
attu 255

X

Xanthidae . 378, 380, 381, 395, 417
Xanthinae 378, 395
Xantho 397
distinguendus 397
neglectus . 378, 380, **397**, 398
Xantho (*Leptodius*) cavipes . . 398
exaratus 398
Xenentodon cancila . . 7, 20, 44
Xenentodontidae 18, 20

MGIPC-M-III-8-21-14-7-38-440.